POWER

Vol. 43 NEW YORK, JUNE 20, 1916 No. 25

An Unconscious Accomplice

A Few Shares Of Stock Will Be Disposed Of To Ministers, Teachers Widows and
Scientists Astounded Power Produced Prodigally
The heat of a candle magnified to the light of a hundred incandescents
Read What the Sunday Mud Says of this Marvellous Invention
If a candle will produce such results — think what a shovel of coal would do.
SUNDAY SUPPLEMENT
C.H. Greeley for Power

The Sunday Newspaper Reporter Getting His Story

Collecting and Preparing Samples of Coal Deliveries

Because the quality of coal is subject to such variation, because its cost amounts to from 20 to 65 per cent. of the total cost of power, more and more care is exercised in its purchase. The samples collected from the deliveries for analysis must be most carefully obtained if fairness to purchaser and seller are to be had.

We have from time to time emphasized the importance of having a competent person select the samples—one who is acquainted with the reason for gathering them and with the causes that lead to misrepresentation. Especially is this true if a penalty is imposed upon the seller. Many argue that an inexperienced person will select the most representative samples. This is another way of saying that ignorance can do better than specific intelligence honestly applied. Never fear taking too large a sample. Errors are almost certain with samples too small. But the bulk of the delivery does not alone determine the weight of the sample. E. G. Bailey[1] has stated this very well when he says: "The larger the size of impurities the larger should be the original sample to prevent excessive error, and the same is true with respect to the quantity of impurities. Some coals contain considerable bone, pyrite, slate, etc., and as pointed out in 'Sampling Coal Deliveries,' Bureau of Mines Bulletin No. 63, '. . . it is evident that including or excluding large pieces of impurities must affect the analysis in a small sample considerably.'"

To show with what accuracy samples may be collected, this same bulletin states that two collectors each took samples of 100 lb. each, and the average of the B.t.u. determinations for the thirteen samples of one collector differed by only 7 B.t.u. from the average of the same number gathered by the other collector.

[1] "How To Sample Coal and Coke," Fuel Testing Co., Boston.

With nearly all soft coals, the sample should weigh not less than 1,000 lb., and if it contains more than the ordinary quantity of impurities, 1,500 lb. should be the minimum weight. With anthracite, particularly the finer grades, from 500 to 800 lb., carefully selected, should give a representative sample. These sample weights hold good for deliveries weighing from a few tons to cargo weights, although from 5,000 to 8,000 lb. as the weight of the gross sample is not too great for cargo deliveries. Most representative samples may be had when the coal is being unloaded from wagons, cars or boats, as then shovelfuls, or little lesser amounts, may be gathered as the coal is taken from different parts of the load. If the samples are not taken during unloading or loading, but are gathered from the load while in wagon, car or boat, the collector must be sure to take coal for the sample from the top, ends, middle, bottom and sides of the load. The collector should try to get a number of lumps in the sample proportionate to the number in the delivery. In sampling from cars or from a number of wagon loads an ordinary kitchen fire shovel may be used, the shovelfuls being put in a water pail and, when it is full, dumped into a box having a capacity large enough to hold the gross sample of 1,000 to 1,500 lb. The box should be well covered. The care used in collecting the sample must be exercised in crushing, mixing, quartering and sealing. The place where the crushing is done must be clean.

The pictures on the opposite page so well show the successive steps in preparing the sample that text description is unnecessary. The quart mason or other equally good fruit jar makes an excellent sample container. At least three samples are taken—one for the buyer, one for the seller and a third for analysis by a disinterested party in the event of a dispute.

The following directions are from the Power Test Code of the American Society of Mechanical Engineers:

Select a representative shovelful from each load as it is drawn from the coal pile or other source of supply, and store the samples in a cool place in a covered metal receptacle. When all the coal has thus been sampled, break up the lumps, thoroughly mix the whole quantity, and finally reduce it by the process of repeated quartering and crushing to a sample weighing about 5 lb., the largest pieces being about the size of a pea. From this sample two 1-qt. air-tight glass fruit jars or other air-tight vessels are to be promptly filled and preserved for subsequent determinations of moisture, calorific value and chemical composition. These operations should be conducted where the air is cool and free from drafts.

When the sample lot of coal has been reduced by quartering to, say, 100 lb., a portion weighing, say, 15 to 20 lb., should be withdrawn for the purpose of immediate moisture determination. This is placed in a shallow iron pan and dried on the hot iron boiler flue for at least 12 hours, being weighed before and after drying on scales reading to quarter-ounces.

The moisture thus determined is approximately reliable for anthracite and semibituminous coals, but not for coals containing much inherent moisture. For such coals and for all reliable determinations, the following method should be pursued:

Take one of the samples contained in the glass jars and subject it to a thorough air drying by spreading it in a thin layer and exposing it for several hours to the atmosphere of a warm room, weighing it before and after, thereby determining the quantity of surface moisture it contains. Then crush the whole of it by running it through an ordinary coffee mill or other suitable crusher adjustable so as to produce somewhat coarse grains (less than $\frac{1}{8}$-in.), thoroughly mix the crushed sample, select from it a portion of from 10 to 50 grams, weigh it in a balance which will easily show a variation as small as 1 part in 1,000, and dry it for one hour in an air or sand bath at a temperature between 240 and 280 deg. F. (this temperature being necessary with coal which is not powdered). Weigh it and record the loss, then heat and weigh again until the minimum weight has been reached. The difference between the original and the minimum weight is the moisture in the air-dried coal. The sum of the moisture thus found and that of the surface moisture is the total moisture.

If a large drying oven is available, the moisture may be determined by heating one of the glass jars full of coal (the cover being removed) at a temperature between 240 and 280 deg. F. until it reaches a minimum weight.

With certain lignites lower temperatures for drying may be advisable.

Preparing a Sample of Coal

Courtesy Commercial Testing and Engineering Co., Chicago.

1. Sample of coal spread out and crushed with tamper

2. Mixing: Form cone-shaped pile by pouring coal from corner of shovel each time

3. Quartering: Divide pile into four equal parts

4. Quartered

5. Diagonally opposite quarters eliminated with shovel and remaining fine coal swept out

6. Remaining two quarters spread out and crushed

7. Mixing (same as No. 2)

8. Quartering

9. Quartered

10. Diagonally opposite quarters eliminated (same as No. 5)

11. Remaining two quarters spread out and crushed

12. Mixing (same as No. 2)

13. Quartering

14. Quartered

15. Diagonally opposite quarters eliminated (same as No 5)

16 Remaining two quarters spread out and crushed

17. Mixing (same as No. 2)

18. Quartering

19. Quartered

20. Diagonally opposite quarters eliminated (same as No. 5)

21. Remaining two quarters spread out and crushed

22. Mixing (same as No. 2)

23. Quartering

24. Quartered

25. Diagonally opposite quarters eliminated (same as No. 5)

26. Remaining two quarters spread out and crushed

27. Mixing (same as No. 2)

28. Quartering

29. Quartered

30. Diagonally opposite quarters eliminated (same as No. 5)

31. Remaining two quarters swept into shovel

32. Placing final sample in air-tight container

Unit No. 3 at Northwest Station

By Thomas Wilson

SYNOPSIS—A compound turbine with high- and low-pressure elements in separate casings, a surface condenser with 50,000 sq.ft. of surface and preheating feed-water tubes, five cross-drum water-tube boilers equipped with chain-grate stokers, superheaters and economizers having a combined capacity to deliver 400,000 lb. of steam per hour. A brief description of this equipment, including physical data and ratios.

During the latter part of September, 1915, Unit No. 3 in the Northwest Station of the Commonwealth Edison Co., of Chicago, was put into service. The turbine of this machine, which has high- and low-pressure elements mounted in tandem on the same shaft and in separate casings, is rated at 45,000 hp. The high-pressure element has ten stages and the low-pressure end four wheels, or two stages on either side of the steam entrance, arranged for double flow, as shown in the sectional view of the turbine presented herewith.

Steam at 230 lb. pressure and 200 deg. F. superheat or at a temperature approximating 600 deg. F. is supplied the turbine. The steam is carried through a 20-in. header to the throttle valve on the high-pressure element. Within the steam chest there are 14 steam admission valves, all under the control of the governor and delivering steam to the upper half of the first stage. There are also four overload valves, each opening simultaneously with one of the last four admission valves. The overload valves do not come into action until normal full load has been reached or a considerable drop in pressure occurs. Through a set of nozzles they discharge steam from the first into the fourth stage. In the high-pressure element the steam expands to 7 lb. below atmospheric pressure. It then enters at the center of the low-pressure turbine and flows in opposite directions through double stages on either side to the condenser.

From the sectional view the general construction of the unit will be evident. It has four bearings, with a shaft in three parts, the greatest diameter of the shaft being 24 in. Through pipe embedded in the babbitt, the bearings are water-cooled. These pipes are in both the upper and lower halves of the bearings and are supplied with water at 50 lb. pressure.

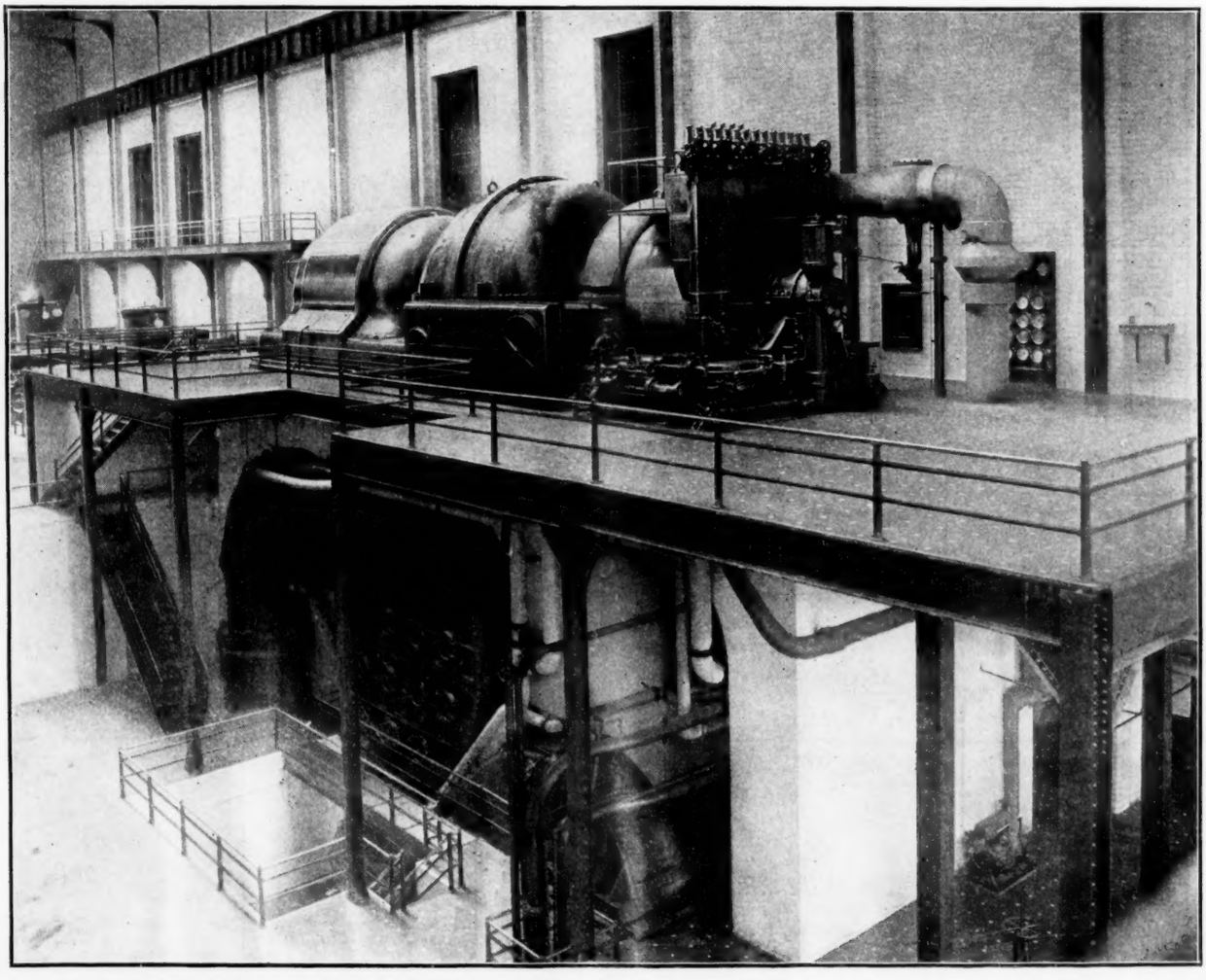


FIG. 1. UNIT NO. 3 AT THE NORTHWEST STATION OF THE COMMONWEALTH EDISON CO., CHICAGO

Oil is supplied to the bearings under forced circulation at a pressure of 20 lb., by a pump geared directly to the main-shaft of the turbine. When starting the turbine, the oil is supplied by an auxiliary steam pump, which is automatically cut out of service by a pressure governor when the unit is up to speed.

The generator, which is a three-phase 25-cycle machine, is wound for 9,000 volts. It has a rated capacity of 30,000 kw. at 100-per cent. power factor, but since being placed in operation it has generated 35,000 kw. for long periods with moderate temperature rise. The machine makes 1,500 r.p.m. A 220-volt exciter is mounted directly on the shaft. Over all, the entire unit is 59 ft. 6 in. long and 18 ft. 4 in. wide, covering a floor area of 1,091 sq.ft., or 0.036 sq.ft. per kilowatt of rating. The height of the unit above the floor is 14 ft. 2 in.

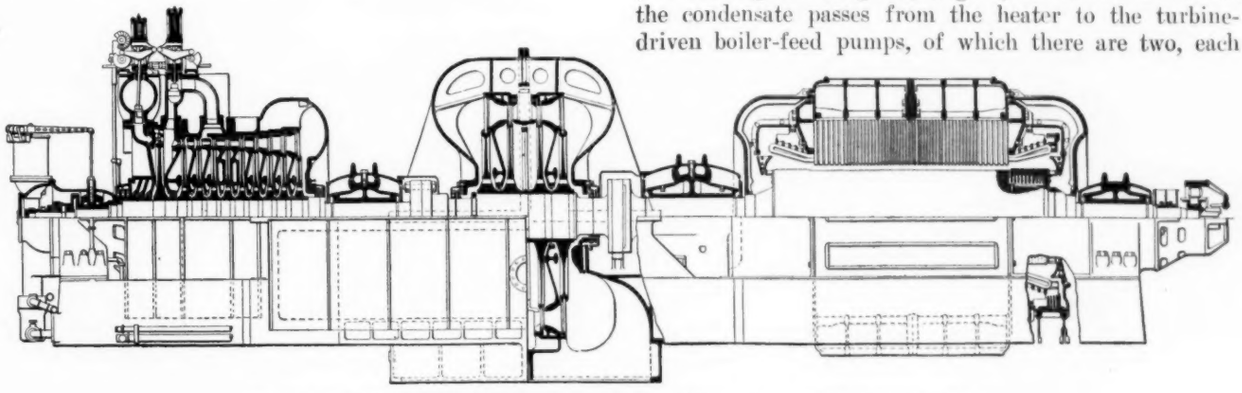


FIG. 2. PART SECTIONAL VIEW OF 30,000-KW. TURBO-GENERATOR

The condenser, with its auxiliaries, was described in the Apr. 6, 1915, issue of *Power*. Briefly, it contains 11,000 one-inch tubes having an aggregate surface of 50,000 sq.ft. It is of the two-pass surface type and maintains an average vacuum of 29 in., or ½ lb. absolute pressure. At rating the condenser will take 360,000 lb. of steam per hour, or 7.2 lb. per sq.ft. of surface. The maximum capacity is 400,000 lb. per hour. Per kilowatt of generator rating the condenser contains 1⅔ sq.ft. of surface.

As shown in the diagrammatic sketch, Fig. 3, circulating water for the condenser is drawn from the intake tunnel by a 48-in. double-suction tri-rotor pump driven directly by a 650-hp. Curtis noncondensing turbine at 1,500 r.p.m. The pump will deliver 52,000 gal. per min. against a head of 17 ft. With the pump working at the rating mentioned and the condenser at its normal capacity, 72 lb. of water would be supplied per pound of steam. The hourly quantity of circulating water would be 3,120,000 gal., and in a day of 24 hr. a total of 74,880,000 gal. would be delivered.

Entering the condenser the steam comes in contact with the preheating feed-water tubes, giving up part of its heat before passing into the condensing space proper. Here the tubes are liberally spaced and are partly arranged in lines parallel to the flow of steam. The air and condensate are taken from the condenser through a single outlet by a turbo air pump on the same shaft as the circulating pump. As the air and water enter the separating chamber of the pump, the air turns off into a separate compartment, from which it is removed by a turbo-air-pump impeller. The water flows by gravity to the other impeller of the pump and is discharged to the preheater at the top of the condenser, where its temperature is raised to within a few degrees of that of the vacuum before it enters the feed-water heater. By exhaust steam from the auxiliary steam-driven units, the temperature of the condensate is further raised in the heater. Any overflow from the heater is discharged into a reservoir, which also receives filtered water for makeup purposes. The makeup water is automatically drawn into the condenser from the reservoir, the connecting pipe having a valve controlled by a float in the heater.

Following the diagram, Fig. 3, it will be seen that the condensate passes from the heater to the turbine-driven boiler-feed pumps, of which there are two, each capable of discharging 450,000 lb. of water per hour at 325 lb. pressure into the economizer. The pumps are of the 6-in. three-stage type with double-suction impellers turning at 2,500 r.p.m. to deliver the quantity of water mentioned.

The boiler-feed pumps discharge to the economizers, which are above the boilers. Two economizers side by side occupy the space above two boilers placed back to back. The economizers are of the Sturtevant high-pressure type. There is one for each boiler containing 456 tubes of $4\frac{9}{16}$ in. outside diameter and 12 ft. long,

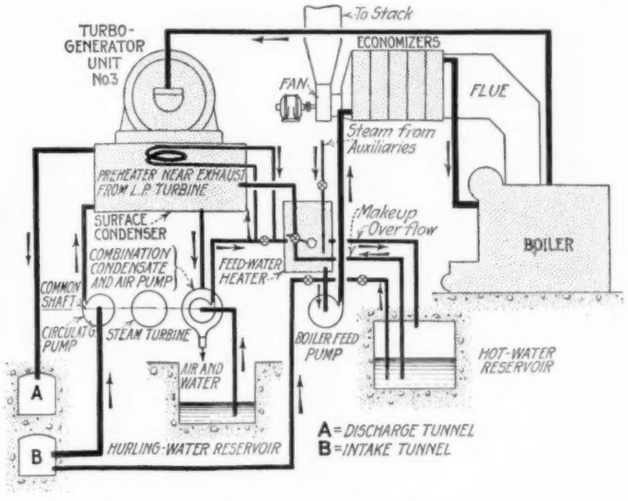


FIG. 3. DIAGRAMMATIC SKETCH OF STEAM AND WATER PIPING

which have a total heating surface of 6,566 sq.ft. The feed water, which has reached a temperature of 100 to 120 deg. F. in the heater, is raised to about 270 deg.

F. in the economizer and at this temperature enters the boiler. Serving each economizer is an induced-draft fan capable of handling 90,000 cu.ft. of hot gases per minute and producing in the uptake of the boiler a draft of 2.4 in. of water. The fan is driven at 300 r.p.m. by a 100-hp. induction motor taking three-phase 60-cycle current at 440 volts.

The steam-generating equipment for the unit consists of five cross-drum water-tube boilers, each having two

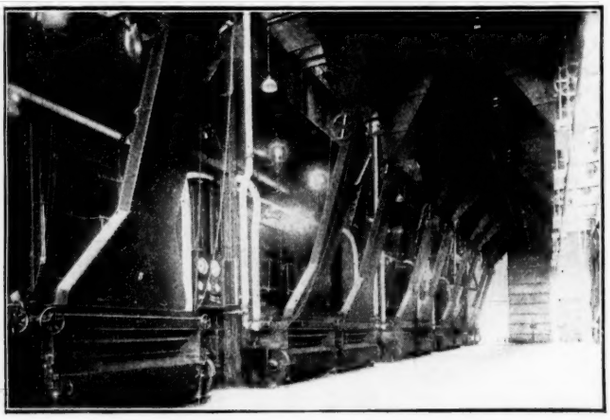


FIG. 4. THE BOILERS SERVING NO. 3. STEAM TURBINE

PRINCIPAL DATA ON EQUIPMENT OF UNIT NO. 3

Turbine

Maker	General Electric Co.
Type	Horizontal compound
Capacity, hp.	45,000
Number single stages, h.-p. element	10
Number of double stages, l.-p. element	2
Speed, r.p.m.	1,500

Condenser

Maker	Wheeler Condenser and Engineering Co.
Number of tubes	11,000
Size of tubes, in.	1
Surface in condenser, sq.ft.	50,000
Surface per kilowatt of generator rating, sq.ft.	1.67
Capacity, lb. of steam per hr.	360,000
Steam condensed per square foot of surface, lb.	7.2
Weight of condenser, empty, tons	176
Weight of cooling water in condenser, tons	66.5
Circulating-pump capacity, gal. per min.	52,000
Circulating-pump capacity, lb. per hr.	26,000,000
Cooling water per pound of steam, lb.	72
Condensate pump, gal. per min.	1,200

Generator

Maker	General Electric Co.
Capacity, rated	30,000
Voltage	9,000
Frequency, cycles	25
Speed, r.p.m.	1,500
Number field poles	2
Length complete unit, over-all ft.	59.5
Width, ft.	18.33
Floor area cover, sq.ft.	1,091
Area per kilowatt of generator rating, sq.ft.	0.036
Exciter voltage	220

Boilers

Maker	Babcock & Wilcox Co.
Type	Cross-drum, water-tube
Pressure, lb. per sq.in. gage	230
Superheat, deg. F.	200
Temperature of steam, deg. F.	600
Number of boilers in unit	5
Number of tubes per boiler	588
Diameter of tubes, in.	4
Length of tubes, ft.	18
Steam-making surface in boiler, sq.ft.	12,200
Stokers per boiler	2
Type of stoker	B. & W. chain-grate
Active area of two stokers, sq.ft.	273
Ratio grate area to boiler-heating surface	1 to 45
Per 1,000 sq.ft. of boiler-heating surface:	
Connected grate area, sq.ft.	22.3
Stack area, sq.ft.	4.17
Economizer surface, sq.ft.	538.2
Capacity of each boiler, lb. steam per hr.	85,000
Evaporation per sq.ft. of heating surface, lb.	7
Coal capacity of each boiler, lb. per hr.	12,600
Coal per square foot of grate, lb.	46
Size of steam main to turbine, in.	20
Boiler-feed pumps:	
Maker	Henry R. Worthington
Type	Turbine driven, three-stage, double-suction impeller
Capacity, lb. per hr.	450,000
Speed, r.p.m.	2,500
Water temperatures:	
In feed-water heater, deg. F.	100–120
Leaving economizer and entering boiler, deg. F.	270

Economizers

Maker	B. F. Sturtevant Co.
Type	High-pressure
Number of economizers	5
Number of tubes in each	456
Length of tubes, ft.	12
Heating surface in tubes	6,566
Maker	B. F. Sturtevant Co.
Type	Multivane
Capacity, cubic feet hot gases per min.	90,000
Horsepower of motor	100
Draft in boiler uptake, in. of water	2.4
Height of stack above boiler-room floor, ft.	250
Diameter of stack, inside, ft.	18

chain-grate stokers. The furnace has a tile roof, and the tubes are vertically baffled. To provide a long flame travel, the first pass is at the rear of the tubes and from the third pass the gases flow upward to the flue just back of the cross-drum. Between the first and second passes, the gases come in contact with the superheater. The tubes slope up and away from the furnace, and the stokers are placed under the low end of the boiler.

Each boiler has 12,200 sq.ft. of steam-making surface, making a total of 61,000 sq.ft. for the turbine. This evaporative capacity serves a turbine which develops 35,000 kw. If we use the term boiler horsepower (based on 10 sq.ft. of surface) there is a ratio of 5.74 kw. per boiler horsepower. Each boiler has 588 four-inch tubes 18 ft. long and contains, as noted, 12,200 sq.ft. of steam-making surface. The active grate area in the two chain-grate stokers totals 273 sq.ft., which bears a ratio to the heating surface of 1 to 45. The operating pressure is 230 lb., the superheat 200 deg. and the capacity of steam per hour for each boiler, 85,000 lb. Per square foot of heating surface this would call for an evaporation of 7 lb. of water per hour. The two

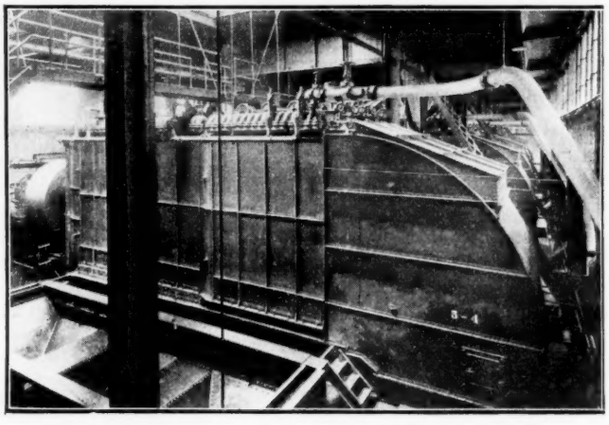


FIG. 5. HIGH-PRESSURE ECONOMIZERS LOCATED OVER BOILERS

stokers can burn 12,600 lb. of coal per hour, or 46 lb. per sq.ft. of grate area.

On a basis of 1,000 sq.ft. of boiler-heating surface the steam-generating installation contains 22.3 sq.ft. of connected grate area, 4.17 sq.ft. of stack area and 538.2 sq.ft. of economizer surface. The stack has an inside diameter of 18 ft. and rises 250 ft. above the boiler-room floor. Many of the foregoing data are collected in tabular form for ready reference.

In previous articles the facilities for handling coal and ashes and the traveling screens for the condenser intake were described. For much of the information and the illustrations presented herewith, we are indebted to Sargent & Lundy, consulting engineers for the Commonwealth Edison Co.

Principles of Phase Converter

SYNOPSIS—An explanation of the principles of the phase converter, showing that it is not essentially different from the induction motor, although the features of a Scott transformer are embodied in it.

The successful application of three-phase traction motors to heavy freight locomotives on the Norfolk & Western Ry., for mountain-grade service, operating under a single-phase transmission, has led many to inquire further into the fundamental principles of the phase converter. This is similar in structural features to the ordinary two-phase induction motor with squirrel-cage secondary combined with the principles of a Scott connected transformer.

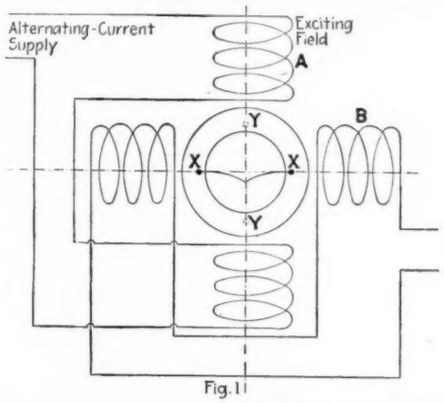


Fig. 1

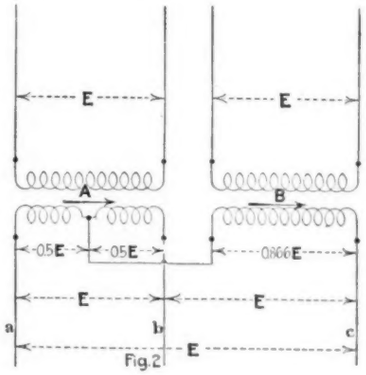


Fig. 2

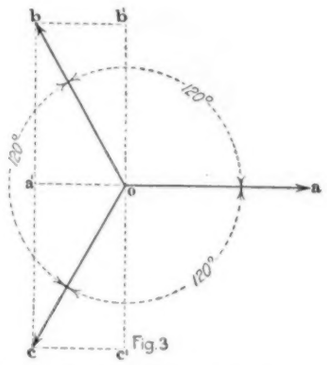


Fig. 3

FIGS. 1 TO 3. SCHEMATIC DIAGRAM OF PHASE CONVERTER AND SCOTT TRANSFORMER CONNECTION

Any polyphase induction motor is inherently a phase converter. For example, while running, if one of the circuits in a two-phase motor be disconnected from the supply system, the motor will continue to run as a single-phase motor and there will be a voltage induced in the disconnected phase approximately equal in value, but at right angles to the supply voltage.

Assume the conditions of a motor with two separate windings on the stator, as in Fig. 1, where A is the primary winding excited from an alternating-current supply and B is the secondary winding on the stator core; XX is the instantaneous position of one coil, closed upon itself, on a rotor revolving at synchronous speed. In this position maximum flux due to the exciting current may be assumed to pass through the coil. As the rotor revolves, one-half a cycle later the coil is in the position YY, at which time the flux due to the exciting current of the stator, passing through the coil, is zero. However, the flux has been maintained in the coil owing to the current in the coil itself. As a result of the change in flux, a self-induced voltage in the coil sets up a magnetomotive force opposing the reduction and therefore endeavoring to maintain the primary flux. If the flux is maximum when the coil is in the position XX, then one-half a cycle later the value will again be maximum in the position YY. Since this flux is at right angles to the axis of the coil, a voltage is induced in the secondary stator winding 90 deg. out of phase in time and space to the voltage impressed upon the primary stator winding similar to that induced in the secondary of a static transformer.

As mentioned before, any polyphase motor can be used as a phase converter. So far, however, only the converter with two primary phase windings has found practical use. Having the two phases, it then becomes possible by means of the so-called Scott connection of the transformer to secure the third phase.

Before considering the phase converter, it will probably simplify matters to first consider the Scott connection of transformers. As previously mentioned, this is a means for changing two-phase alternating current into three-phase or *vice versa*. Fig. 2 shows diagrammatically the Scott connection, which consists of two transformers A and B, their windings on the two-phase side being the same. On the three-phase side transformer B has only 0.866 the number of turns as that in transformer A, with one terminal of B connected to the middle point of A. This gives a voltage relation on the windings as indicated—$0.866E$ on B and $0.5E$ on each section of A.

Let the arrows on the windings represent the positive direction of the voltage. Then the voltage between a and b may be represented by the line oa, Fig. 3. Pressure measured between b and c will be the resultant of the e.m.f. in the right-hand section of A combined with B. Tracing the circuit from b to c, it will be seen that the e.m.f. in the A section is opposite to that in B; therefore the e.m.f. between b and c may be represented on the vector diagram by oa' drawn in a negative direction

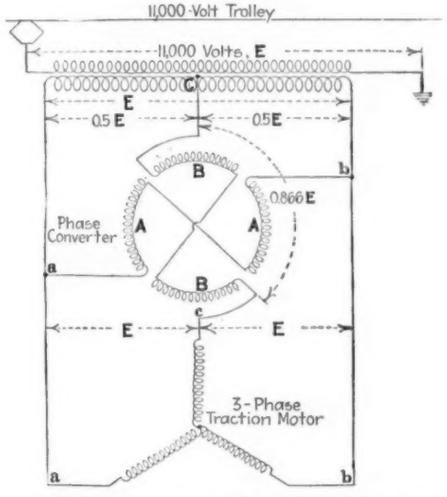


FIG. 4. DIAGRAM OF CONTROL, MOTOR AND CONVERTER

equal 0.5*oa*, and *ob'* drawn in a positive direction at right angles to *oa* and equal 0.866*oa*. Combining *oa'* and *ob'* vectorially gives the resultant *ob*, which is equal to *oa* and displaced in phase from it by 120 deg.

The potential between *a* and *c* will be measured by following out the circuit from *c* to *a*, where it will be

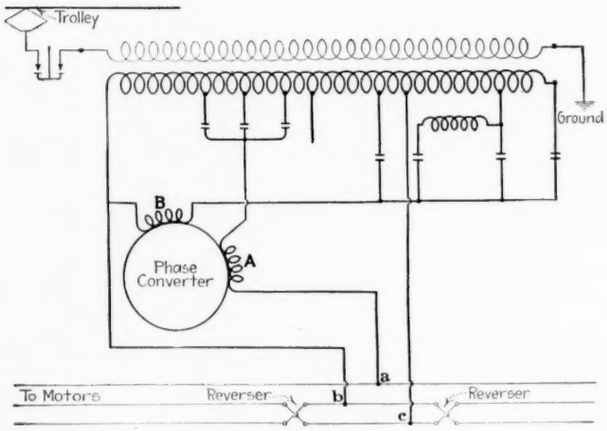


FIG. 5. VOLTAGE-CORRECTING SWITHES

seen that the e.m.f. is in a negative direction in both cases. For this condition the e.m.f. in *A* may again be represented by the line *oa'*, but that in *B* will be represented by the line *oc'* drawn in a negative direction 90 deg. from *oa*. Combining *oa'* and *oc'* vectorially, the resultant *oc* is obtained, which is also equal to *oa* and displaced from *oa* and *ob* by 120 deg. This gives three equal e.m.f.'s displaced in phase by 120 deg., which is the condition in a three-phase circuit.

Fig. 4 shows the phase converter connected to the transformer and stator winding of the three-phase traction motor. This connection gives the same voltage relation between *a*, *b* and *c* as that in Fig. 2. Terminals *a* and *b* come direct from the single-phase transformer and correspond to transformer *A*, Fig. 2. In the phase converter a winding *A* is connected across the secondary terminals of the single-phase transformer, which takes power from the transformer to drive the converter as a single-phase motor. Winding *B* in the converter has only 0.866 the number of turns that winding *A* has, consequently the e.m.f. induced in it will be only 0.866

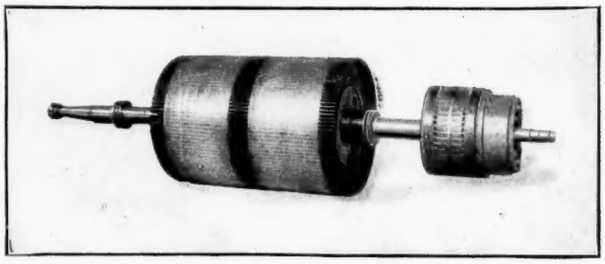


FIG. 6. ROTOR OF PHASE CONVERTER

times that applied to *A*. As explained in Fig. 1, the e.m.f. in *B* will be 90 deg. out of phase with that in *A*. Connecting winding *B* to the middle of the transformer gives the same condition as in Fig. 2, namely, a winding with 0.866 *E* volts induced in it, tapped into the middle point of a second winding having *E* volts, 90 deg. out of step with the first; therefore the same voltage relation will be obtained between terminals *a*, *b* and *c* (Fig. 4) as in Fig. 2.

To correct for unbalance of three-phase voltages due to varying loads and speeds, the impressed voltages are changed by closing different switches, after the manner shown in Fig. 5.

Since only single-phase power is available on a locomotive, it becomes necessary to start the converter by an auxiliary starting motor. The series characteristics of the commutator-type single-phase motor renders it most suitable to this application. A special connection on this motor makes it automatically fool-proof against overspeeding the converter before power is applied to the latter. The converter is started by a switch, and from actual readings taken can be brought up to speed and thrown on the line in less than 15 sec.

The control embodies necessary protective apparatus which breaks the connections to the phase converter after approximately six seconds of interrupted power

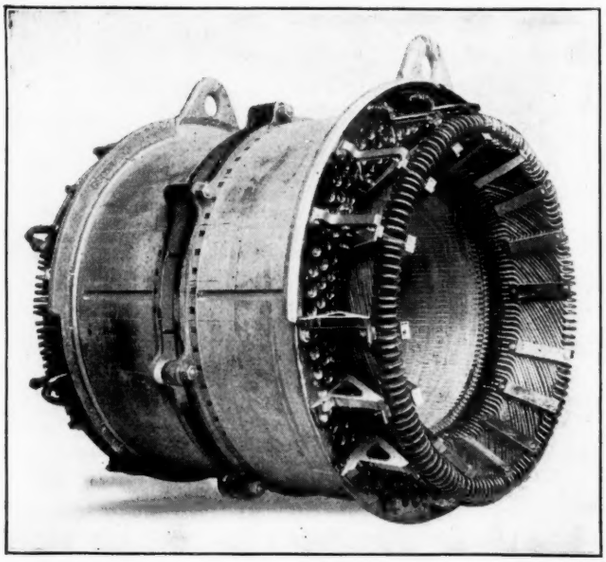


FIG. 7. STATOR OF PHASE CONVERTER

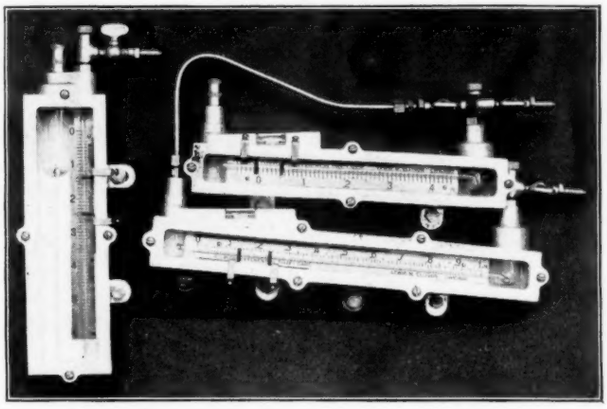
supply. This is to prevent possible application of power at a speed below that at which the converter will pull into synchronism.

The rotor is of simple construction. The upper half of the converter frame is eliminated, and the stator core can be raised from or lowered into the frame and securely bolted in place. The bearings or bearing caps can be lifted vertically. The starting motor is mounted similarly in the frame casting and is designed so that the brushholder, brackets, stator or rotor each can be independently removed.

A Boiler May Be Warmed up, as is done with marine boilers, by blowing steam into the cold water, but in stationary plants the necessary appliances are rarely fitted. In such plants, where steam has to be raised rapidly, a good plan is to nearly fill the boiler with water, then the whole body of water above the firebars will grow hot, while that below the furnaces remains cold. As soon as the boiling temperature has been reached and steam is being generated, the blowoff cock should be opened and the lower cold water run out until the hot water reaches the boiler bottom. The whole boiler will then be of a uniform temperature, and the raising of steam can be proceeded with at a rapid rate.—C. E. Stromeyer.

Ellison Forced-Draft Gages

A series of four gages for use in connection with underfeed stokers and forced-draft furnaces has recently been perfected by Lewis M. Ellison, 214 W. Kinzie St., Chicago, Ill. These four gages, known as the U-multiple differential, the U-twin differential, the U-combination differential and the U-differential, are each a combination



ELLISON MULTIPLE DRAFT GAGE

of the new U-draft cover type gage reading to 6 in. of water with various combinations of the standard Ellison differential draft gage.

The U-multiple differential draft gage is shown in the accompanying illustration. It consists of the multiple gage and the cover type U-gage mounted on the same base complete with connections and dustproof vent caps. The U-gage indicates the blast, the upper incline gage the furnace draft and the lower incline gage the drop between the flue and furnace drafts. Each gage has movable pointers, the range of each scale being indicated. For balanced draft the furnace gage has a scale reading 0.05 in. to the left of zero for momentary pressures in the furnace above the atmosphere and 0.45 in. to the right of zero for the suction, the liquid movement being multiplied 15 times. On this gage the indicating tube lies near the upper edge of the scale, bending down at the chamber to prevent the liquid pulling through from a momentary excess furnace draft.

The U-twin differential draft gage is identical with the U-multiple except that the differential gages are not cross-connected, the upper one being connected with the furnace and the lower one with the flue. The U-combination differential consists of a U-gage and a combination differential gage so connected as to make draft measurements either in the furnace or the flue, or by using both ends to show the drop through the setting. The U-differential is for use where differential readings between the flue and furnace on the incline gage are not desired. It consists of the U-gage and a single incline gage, piped to indicate either furnace or flue draft.

With the U-gage reading to 6 in. of water so that it may indicate the blast, it will be possible to regulate closely the air supply and as a consequence maintain a uniform percentage of CO_2. There is also the possibility of reducing the power required to drive the blast apparatus.

Projected Area of a Bearing is equal to the diameter of the shaft multiplied by the length of the bearing.

For the Want of an Air Cock

By H. G. Gibson

The fireman was a green hand, the engineer was a new man on the job, and—well, here's the whole thing in detail:

"Mr. Brown!" shouted the fireman, poking his head through the engine-room doorway; "I can't get any water into the boilers."

"What seems to be the matter?" queried the engineer as he started into the fireroom.

"I don't know. I was cleaning the fire under No. 1, and before I knew what was happening the boilers got too full of water. I shut the pump down for a few minutes, and when I started it again it would not pick up water. I have been trying to get it doing something but couldn't."

The balky pump was working as though the suction line had been suddenly changed from water to air. The water was still in sight in all of the boiler gage-glasses, but only about an inch and "going down," so something must be done quickly.

Brown made an effort to think calmly—to reason it out. "No use starting the other pump," he said to himself, "for the trouble seems to be the lack of water in the heater. Maybe the supply pipe to the heater is choked up." There was a storage tank full of water in the sub-basement, so he opened the suction valve to that tank hoping to see the pump get to work—but there was "nothing doing."

The water was now just in sight, and unless something was done right away the fires would have to be killed. He did not open the air-cock on the water end for the good reason that there was no air-cock there—only a plug. "That's a devil of a note! If it just had an air-cock on that water end, I might be able to do something, for the trouble seems to be in the pump as well as the heater. I'll start the other pump—that has an air-cock." Suiting the action to the word, the pump was started, but acted just as its mate had, but the open air-cock was spurting steam and hot water all over the platform.

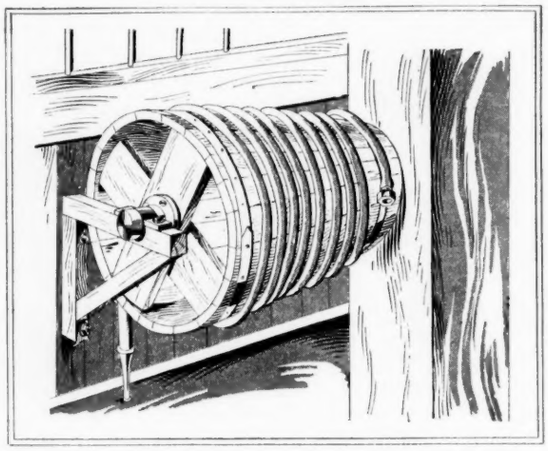
"I've got it!" he said to the fireman. "Shut the feed line valve to No. 1 boiler." The fireman did as he was directed, but with no results. "Open that and close No. 2 valve." Still no results. "Open that and shut No. 3 valve."

Sure enough, as soon as No. 3 boiler-feed valve was shut, the intensity of the stream of water and steam issuing from the open cock on the pump diminished and presently ceased altogether, and the pump went right to work just as a respectable pump should.

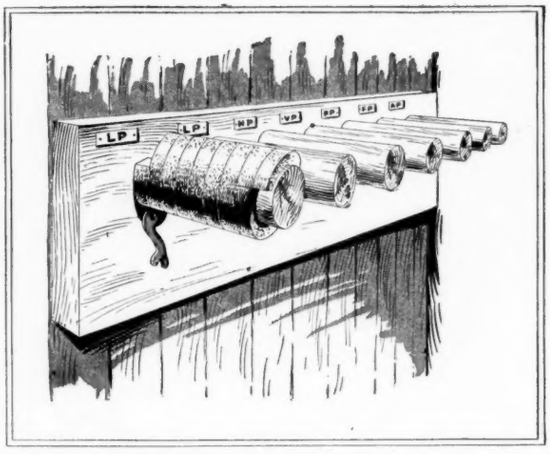
Moral: Always have a cock on the water end of the boiler-feed pump; then, if the pump acts as though it had lost its suction, you can tell by opening the cock whether the cause is air or steam from the boilers backing out into the pump chamber through a leaking check valve on the boiler-feed line.

As a Result of the War, Ocos, Guatemala will lose its electric-lighting plant. About nine years ago the Kosmos liner "Sesostris" was beached near there, and the chief engineer arranged to supply the town with electricity, after it was decided not to refloat the ship. Now the demand for vessels has reached a point where it appears profitable to dig a canal and float the ship back to sea, says the "Electrical Review" (London).

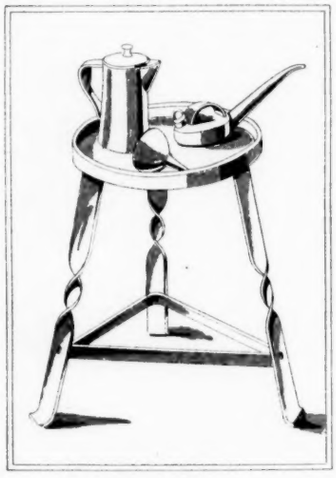
Handy Hints and Clever



A Home-Made Hose Rack

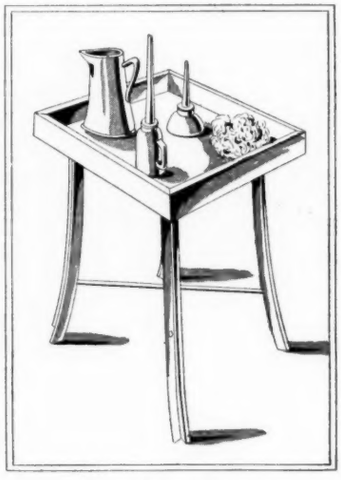


Handy Rod-Packing Rack

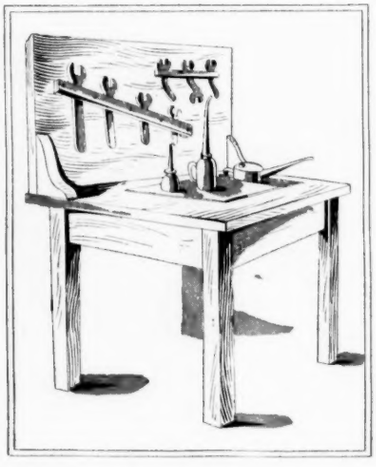


Oil-Can Stand

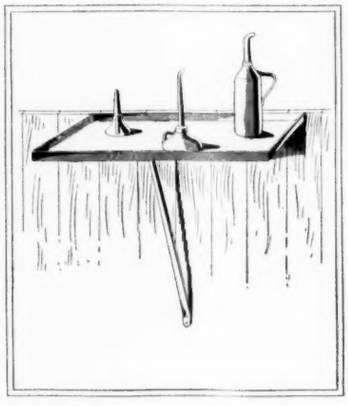
Portable Tool Stand



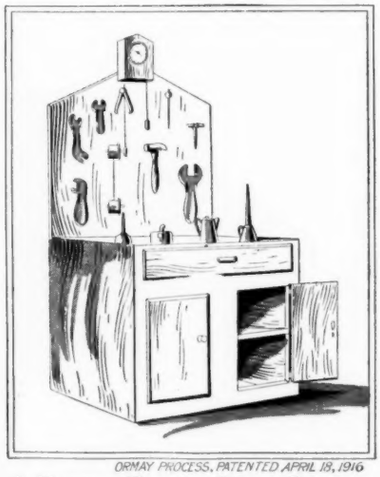
Oil-Can Table



Combination Table and Wrench Board



A Convenient Shelf for Oil Cans

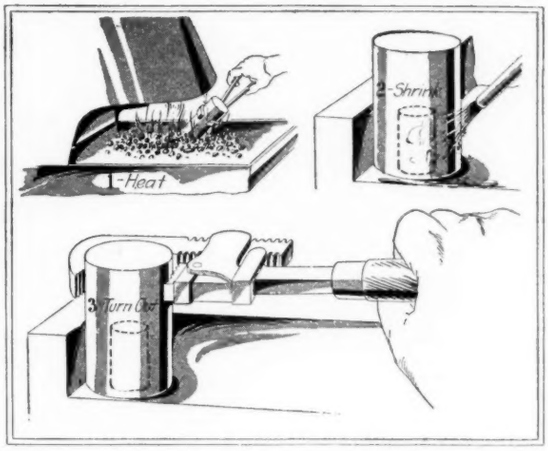


ORMAY PROCESS. PATENTED APRIL 18, 1916

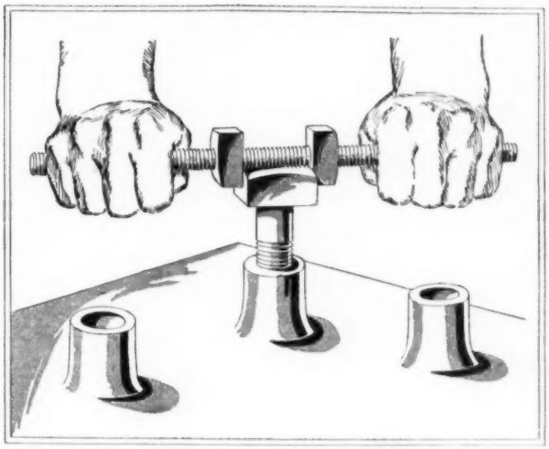
A Useful Engine-Room Cabinet

Engine-Room Furniture That is Easily Made

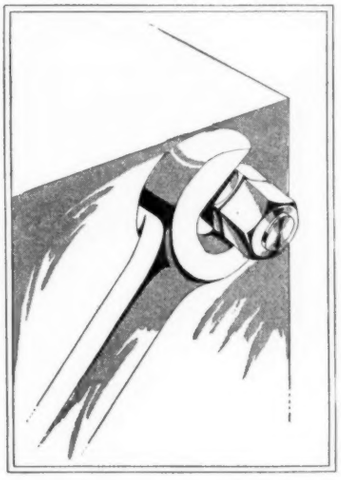
Kinks for the Power Plant



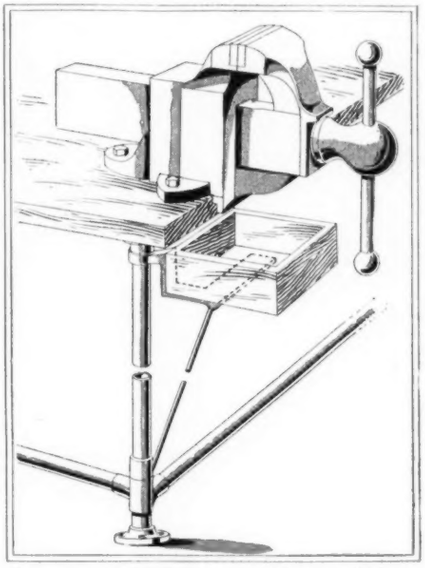
Getting a Grip on Tightly Driven Pin



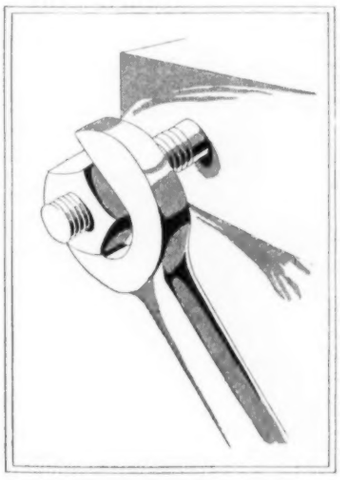
A Quickly Made Emergency Wrench



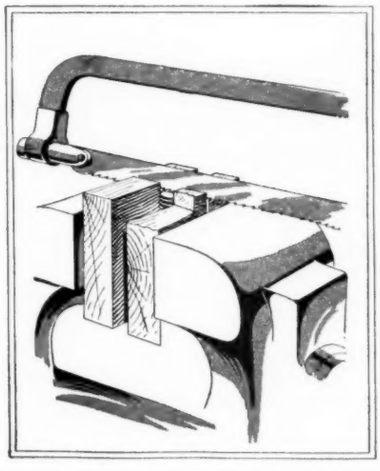
Pulling a Stud with Locknuts



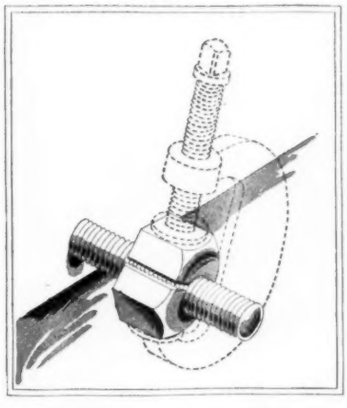
Swinging Drawer for Small Tools



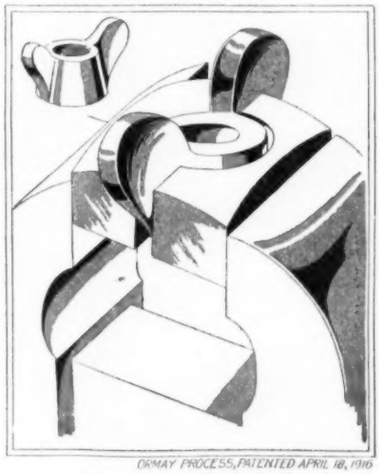
Pulling Stud with a Shrunk Nut



Holding a Screw for Slotting



Pulling a Stud with a Split Nut



Wing Nut Held by Split Nut

Some Stunts That Work Out In Practice

Horizontal and Vertical Baffling

By S. H. Viall

SYNOPSIS—A comparison of horizontal and vertical baffling for boilers of the Babcock & Wilcox type. With the former, slightly higher over-all efficiency may be obtained, but the additional upkeep and operating expense more than counterbalances this gain. Horizontal baffling reduces smoke, and for this reason it is frequently warranted.

Boilers of the Babcock & Wilcox type have been equipped with numerous types of horizontal baffling, and in almost every case the purpose has been to reduce the smoke. By changing from the vertical to a horizontal pass, a longer flame travel can be had between the furnace and the tube region without increasing the floor space occupied by the furnace and boiler. The draft loss in this kind of boiler, vertically baffled, operating at rated capacity or above, using a noncaking free-burning coal with the fuel bed 6 to 7 in. thick and a ratio of heating surface to grate area of 50 to 1, will be about 50 per cent. Under similar conditions with horizontal baffling, the draft loss will be approximately 65 per cent. Thus with a draft of 0.5 in. on the stack side of a wide-open damper and a reasonably clean tube region, there will be about 0.25 in. of draft over the fire if the boiler is vertically baffled and 0.18 in. if horizontally baffled, with the usual arrangement of tile and passages.

Increasing the Flame Travel

Figs. 1, 2, 3 and 4 show four general methods of increasing the flame travel for the smokeless operation of B. & W. boilers burning high-volatile coals. The vertical-header single-decked boiler is shown herewith. In Figs. 1, 3 and 4 it is 14 tubes high, and in Fig. 2 it is 9 tubes high. The text will apply to the inclined or vertical header and to single or double-decked boilers.

Figs. 1 and 2 show the types of horizontal baffling usually selected when a sufficient flame travel for reasonable smokeless operation cannot be had with the standard vertical baffle. In many installations, changing from the vertical to the horizontal baffle has been effected with but minor changes in the setting, piping, breeching or building. Occasionally, to get sufficient area below the tubes, it is necessary to lower the furnace 24 to 30 in. Sometimes the combustion chamber needs to be lowered correspondingly, or local conditions may be such that it is less expensive to tear down the setting, raise the boiler, change the piping and breeching and rebuild than to lower the furnace or combustion chamber. In any event careful consideration must be given to the area of the gas passages.

The Sewell baffle, Fig. 1, is adaptable to B. & W. boilers 12 to 14 tubes high. With adequate draft, boilers baffled in this way are operated at from 150 to 170 per cent. of rating with satisfactory results. Care must be used to keep the "corners" clean. Ordinary steam blowing of the tube region through the regular soot-blowing holes will not suffice. Special clean-out doors should be provided, as indicated at *A*, *B* and *C*.

With this type of baffling, the gases, before reaching the superheater, travel over a larger proportion of the heat-absorbing surface than in the ordinary vertically baffled boiler. This results in the gases entering the superheater at a lower temperature. For example, with the vertical baffling the gases may reach the superheater at a temperature of 1,000 to 1,100 deg F. and produce

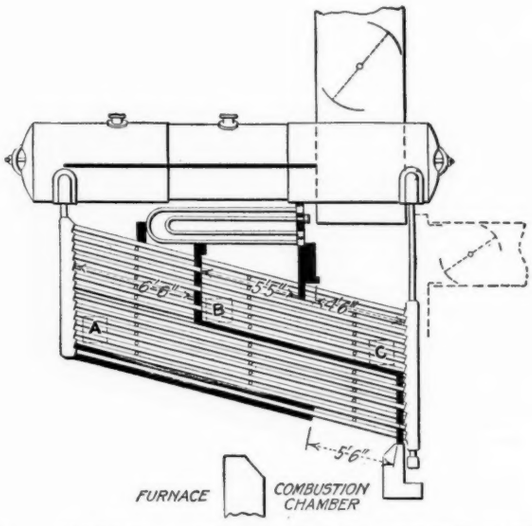


FIG. 1. BABCOCK & WILCOX BOILER, SEWELL BAFFLE

a superheat of 180 to 200 deg. With the Sewell baffling the gas temperatures would be 800 to 900 deg. F. and the superheat, 120 to 140 deg. The efficiency of the boiler is about the same in either case, but with the Sewell baffling the furnace efficiency is apparently a little higher on account of the more thorough mixing of the volatile gases and the air as they change their direction of travel when passing from the fire to the tube region.

Table 1 gives the average results of several tests upon two 500-hp. B. & W. boilers—one with the standard vertical baffling and the other baffled as in Fig. 1. The draft loss through the boilers used in these tests was 42 per cent. with the vertical baffle and 61 per cent. with the Sewell baffle. The fuel was a free-burning noncaking coal 8 to 10 in. thick on the grates. The draft loss is less than the assumptions made at the beginning of this article, but the reason is the greater thickness of the fuel bed.

In these particular tests 58 per cent. of the draft was available over the fire with the vertical baffling and 39 per cent. with the horizontal baffling, a difference of 19 per cent. Yet with this greater draft loss there was a drop of only 3.5 per cent. in capacity, because of the difference in furnace conditions brought about to accommodate the furnace to the changes in baffling. That the furnace conditions were improved is shown by the fact that both boilers absorbed 71.88 per cent. of the heat delivered to them, but when the combined efficiencies of the boiler and furnace are considered, the Sewell baffling has the slight advantage of 1 per cent. in economy.

On other boilers the evaporation from and at 212 deg. F. appeared to be about 3 per cent. better with the

Sewell baffling. The results are given in Table 2, and the figures, as in Table 1, are averages.

It is frequently claimed that changing from the standard vertical to a horizontal baffling such as the Sewell seriously interferes with the efficiency of the boiler. The

TABLE 1. BOILER EFFICIENCY WITH STANDARD AND SEWELL BAFFLING

	Standard Vertical Baffle	Sewell Baffle
Efficiency based on combustible consumed, per cent.	71.88	71.88
Efficiency based on combustible supplied furnace, per cent	68.67	69.41
Horsepower rating	500	500
Horsepower developed	893	862
Percentage of rating developed	179	172
Draft in uptake, stack side of damper, in.	1.33	1.37
Draft over fire, in.	0.78	0.54
Percentage of draft available over fire	58	39

examples cited are typical of average cases. It can be said that with proper design the Sewell baffled boilers for similar conditions will on the average give as good thermal efficiency as those vertically baffled and probably will give slightly better combined furnace and boiler economy.

The horizontal baffling, however, has several disadvantages which counteract the slight gain in thermal efficiency. These are not as serious with boilers having sufficient draft and operating at less than 130 per cent. of rating as with boilers that are forced or have poor draft facilities. The additional expense incurred in operating a horizontally baffled boiler is caused by the extra work of cleaning the tube region, replacement of the baffle on the lower row of tubes, extra labor in cleaning the combustion chamber, more frequent renewals of furnace parts, especially if equipped with a stoker, and the increase in tube renewals.

Care must be exercised in keeping the tube region clean, for if soot is allowed to gather in the corners,

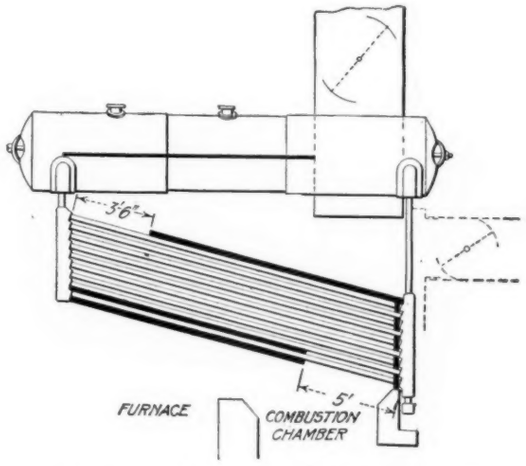


FIG. 2. SPECIAL HORIZONTAL BAFFLE

as at *A*, *B* and *C*, Fig. 1, it soon accumulates in such quantities as to decrease the draft and diminish the coal-burning capacity of the furnace. If attempts are then made to force the furnace to burn fuel enough to carry the load, excessively high temperatures will be had, resulting in more rapid destruction of the brickwork.

Box tile on the lower row of tubes will last from a few weeks to a year or two, depending upon the capacity developed and assuming proper draft. If the draft is not adequate the best fireclay tile may be quickly melted away. The tendency of the hot furnace gases is to rise. The angle and position of the lower baffle prevent the gases from taking their natural course, which results in their being impinged against the baffle with a strong scrubbing action. If the temperatures are high enough to soften the tile and the velocity of the gases sufficient to carry small particles of coal and coke off the grates, the erosive action on this baffle will be noticeable.

In the vertically baffled boiler fine combustion dust gathers in the chamber below the second and third passes.

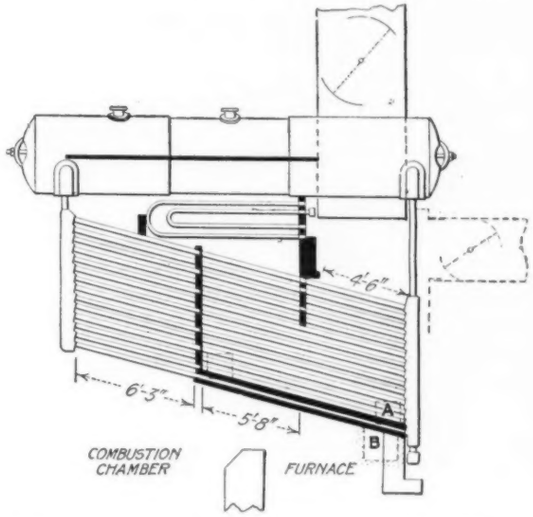


FIG. 3. COMBINATION OF HORIZONTAL AND VERTICAL BAFFLING

If the baffling is changed to the horizontal type, much of this refuse gathers in the combustion chamber. It may be in the form of dust if only moderate furnace capacities are developed, but it is almost certain to fuse to a hard rocky slag if the furnace and combustion-chamber temperatures are high. It is possible that this slag may be hard enough to require sledge hammer and chisel to break it loose. The time required for cleaning the combustion chamber may be seven or eight times as much as required to clean the same space under the vertically baffled boiler.

Destruction of the brickwork may be hastened by thoughtless use or careless operation of the dampers, and especially with the automatic damper regulator. This evil is caused by closing off or severely checking the air supply to a furnace whose temperature is near the melting point of the brick. Throttling the air supply will cause a rise in temperature, which may reach a point that will be destructive to the brickwork. The effect is the same as forcing a furnace with insufficient draft and will be more marked with the horizontal baffle than with the vertical pass, on account of the heat reflection from the surrounding firebrick surfaces. Although the firebrick-inclosed furnace of the horizontally baffled boiler permits of better furnace efficiency, especially noticeable in connection with most mechanical stokers, there is the disadvantage of high maintenance expense of the brickwork, furnace arches, side walls, bridge-wall and lower baffle.

Steam made in the bottom row of tubes of the boiler shown in Fig. 1, between the rear header and the horizontal baffle, must travel approximately 12 ft. through an inclined tube, up the header and through the top nipple into the drum. Steam and water circulating from 13 other tubes must also pass through this same nipple.

If the boilers are operated at approximately 200 per cent. of rating steam is generated so fast in the bottom tubes that the tube surface is not always effectively covered with water, resulting occasionally in blistered tubes. The blisters form near the end of the baffle, even on tubes that show no sign of scale or oil.

Comparing the horizontally baffled boiler with those vertically baffled, the net operating expense in excess of the saving effected by the higher thermal efficiency of the former is approximately 10 to 50c. per rated horsepower per year, varying with the local conditions. The skill of operation, the draft facilities and the capacities developed are the principal factors affecting the net results.

However, the additional expense per unit of rating is comparatively small, even in the economical plants run at high capacity, so that cities are warranted in requiring owners to change from the vertical to the horizontal baffle, if that course is necessary to get smokeless operation. During May, 1914, a group of engineers with broad acquaintance in Chicago met and were discussing some of the points presented in this article. They counted 223 B. & W. boilers, aggregating 104,202 hp., installed in the city having some form of horizontal baffling.

Table 2 gives data from tests made on 400-hp. boilers to determine the relative results to be had with the standard vertical baffle and the Sewell baffle. The coal

TABLE 2. RESULTS FROM COMPARATIVE EVAPORATIVE TESTS ON 400-HP. BOILERS

	Standard Vertical Baffle		Sewell Baffle
Equivalent evaporation from and at 212 deg. F. per lb. of dry coal, lb.	8.20	8.12	8.46
Horsepower rating	400	400	400
Horsepower developed	568	365	526
Percentage of rating developed	142	91	132

used in these tests had a heat value of approximately 11,000 B.t.u. per lb. and was from the same car, a wheelbarrowful being taken for each furnace in rotation. Therefore the equivalent evaporation figures are comparative. The plant has three batteries of two boilers each and a steel stack directly above the center line of each battery. This combination made easy a comparison of the smoke produced by the different units tested.

The vertically baffled boiler at 142 per cent. of rating gave continuous smoke ranging from No. 2 to No. 3 on the Ringelmann scale; it was of No. 3 density about 20 per cent. of the time. At 91 per cent. of rating the smoke was continuous and ranged from No. 1 to No. 2. With the Sewell baffling there was little visible smoke. For the few minutes that smoke was visible, it was less than No. 1. In the comparative tests of Tables 1 and 2 the same make of stoker was used and only minor changes were made in the furnaces.

Sewell baffling is seldom satisfactory in boilers less than twelve tubes high, unless they are operated at moderate capacities. The B. & W. boilers, nine tubes high will usually give best results, smoke considered, with the straight horizontal baffling upon the lower and upper rows of tubes, as in Fig. 2.

Whether the gases flow at approximately right angles across the tubes or along their length has but little effect upon the thermal efficiency. The personal element in operation has a far greater influence upon the results. With horizontal baffling it is advisable to protect the rear headers, as shown in Figs. 1, 2 and 4, to limit steam generation in the header and obviate interference with the circulation. At high capacities the circulation might be so impeded as to cause the blistering of the tubes previously mentioned.

As shown in Fig. 4, the Bement baffle was designed to give a longer flame travel between the furnace and the tubes, for a given floor space, and to retain the feature of the gases crossing the tubes at approximately right angles. This style of baffling changes the location of the uptake and one or more of the steam outlets, so that it does not lend itself readily to alterations in existing plants. It exposes the full height of the rear header, the rear circulating nipples and a section of the drum to much higher temperatures than is the case with the standard baffle. This condition increases the tendency to interfere with proper circulation. Gases going from the first to the second pass follow the line *CD*, Fig. 4, and practically bypass that portion of the superheater

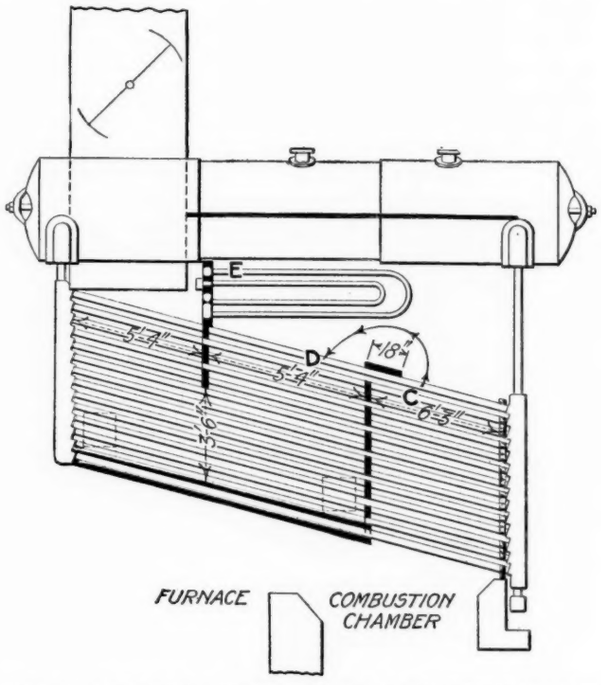


FIG. 4. ANOTHER COMBINATION OF HORIZONTAL AND VERTICAL BAFFLING

at *E*. The tile on the lower tubes are subject to just as hard service as in Figs. 1 and 2.

Fig. 3 shows a type of baffling especially adaptable to high-capacity work, as it avoids many of the objections to the Sewell and Bement baffling. This type of construction can be used to advantage only on new installations, because of the headroom required and the rearrangement of the boiler-room layout caused by the furnaces being placed under the mud drum. The furnace gases first come in contact with the tubes near the front header, and no trouble is experienced with blistered tubes. The gases make but one vertical pass before reaching the superheater, so that the superheat is as high as with the standard setting. The tubes rise as they go away from the furnace, giving increased combustion-chamber space, which is an advantage for high-capacity work. The incline of the baffle is with the natural travel of the gases instead of opposing them, and therefore the erosive action on the tile is not as severe as with the other styles of baffling shown. There are two corners for soot accumulation. Provision can usually be made for a settling

chamber, as shown in dotted section at *B*, Fig. 3, and thus move the clean-out door *A* downward.

The possibility of having the escaping gases pass to the breeching, either through the circulating nipples or around the drums, is shown in Figs. 1, 2 and 3. Other circumstances permitting, it is advisable to use the uptake around the drums. This arrangement reduces the friction of the gas flow increasing the draft over the fire.

Margin of Power in Internal Combustion Engines

By R. E. Mathot

SYNOPSIS—Factors affecting the capacity of gas and oil engines, and present practice in rating these engines.

In the early days, about 1890, when the gas engine came into practical use for small industries requiring from 4 to 30 hp., probably 80 per cent. were supplied by England because of the low price and simple and reliable construction. Compared to the steam plant needing special attendance and occupying a larger space in the factory, the gas engine proved so convenient that the users were satisfied as it was, and did not impose more exacting conditions upon the makers. Whether the guaranteed power was developed was seldom discussed, for the buyers relied confidently upon the figures mentioned in the contracts or written agreements. The use of an indicator and rope or prony brake was confined to the shop where the engines were built.

Early Builders Overrated Engines

That the gas engines were not delivering their rated outputs was later discovered where they were installed in the place of steam engines, making possible a comparison between their powers; also when gas engines were called upon to drive dynamos and so allowed the verification of the horsepower developed.

It happened often that by reason of competition the agent, instead of guaranteeing his engine for, say, 25 hp., thought that he could as well sell it for a 26.5-hp. engine, because it delivered such power at the manufacturers' shop. The purchase was then settled under these conditions, the contract signed and the agent undertook the installation. However, instead of running water, as in the shop test, thermo-siphon reservoirs were used. Sometimes the engine was placed far from the gas meter, necessitating long gas pipes. Also, to comply with local conditions, long exhaust pipes were often employed and an additional silencer box to prevent troublesome noise. Of course no attention was paid to the altitude or to the prevailing room temperature. Where only part of the foregoing factors were present, they might have caused a drop in power of 5 to 10 per cent.; if all existed, the loss might be 15 to 20 per cent.

Suppose the engine had been installed with normal water cooling and reasonable length of supply and exhaust pipes in a shop of favorable temperature, but not regulated experimentally with the aid of an indicator diagram, it might have delivered 25 b.hp. for which it was built, but not 26.5 hp., which it occasionally developed for half an hour when the valves were newly ground, the piston rings perfectly tight and special lubricating oil used.

Assume, further, that the engine, under these good working conditions, was erected at an altitude of, say, 3,300 ft., then the loss in power would be about 10 per cent. as a consequence of the dilution of the air under lower atmospheric pressure. It may be stated roughly that 3 per cent. of power is lost per 1,000 ft. increase of altitude. For the same reason expansion of the air fed, due to a rise in temperature, will proportionally decrease the power. Of course the combined result of barometric pressure and high temperature may affect the power to a marked extent.

Leaky valves and pistons and defective lubrication are other factors responsible for loss of power. An oil that loses its viscosity under high temperature may greatly decrease the mechanical efficiency. I have known cases where from 10 to 15 per cent. power was lost through the use of oil which, although satisfactory for steam engines, did not answer the requirements of cylinder lubrication for internal-combustion engines.

The same conditions relate to engines running on natural gas, the composition of which keeps constant within narrow limits.

Loss of Power with Producer Gas

There are additional reasons for loss of power when dealing with producer gas, as its quality is subjected to continuous changes in pressure, composition and temperature. These variables depend as much on the nature of the solid or liquid fuel used in the producer as upon the producer's operation. Take, for instance, a suction producer working on anthracite. As soon as the amount of ash under the incandescent zone increases, there is an abnormal suction resistance created through the fuel bed, resulting in insufficient gas entering the engine cylinder. Hence the proportion of air increases and makes the mixture so lean that the mean effective pressure may fall from 70 to 40 or 50 lb. This detrimental increase in ash is likely to occur several times a day if the operator does not clean the fire regularly. Also, if the coal has a tendency to clinker and fuse, if not poked in due time, pockets or arches are likely to form in the fuel bed and disturb the chemical conversion of the CO_2 into combustible CO.

If the engine is working close to full load and cleaning of the fire is not done rapidly enough to prevent an abnormal amount of air getting into the ashpit, to the detriment of the steam admission, the gas production is again disturbed by lack of hydrogen. On the contrary, if the fire is recklessly poked and much incandescent ash allowed to drop in the water bed of the ashpit, an excess of steam generated suddenly may lead to a corresponding excess of hydrogen in the gas, which is likely to cause

preignitions and slow down the engine. Insufficient water or too hot water for the proper cooling of the gas after it leaves the producer may increase the temperature so much that the proper amount does not enter the cylinder and the engine output is reduced.

To a greater extent these same conditions apply to engines operating on gas from blast furnaces and coke ovens, which are in reality huge gas producers. They place the gas engine that has no surplus available power in the same predicament as a steam plant in which the boiler is too small to generate the steam required by its engine. Bad coal, improper poking of the fire, excess of ash and lack of cleaning would cause the pressure of the steam to drop enough to slow down the engine if originally overloaded or if not powerful enough for the work it has to perform; and this defines in a few words all the troubles experienced with overrated gas engines.

Of course a steam engine is less likely to be affected in its power through lack of steam pressure because the governor will allow for more admission as the pressure decreases. Moreover, the steam engine is usually rated for a power corresponding nearly to its best economy, which is far from being its maximum. A steam engine rated at 100 i.hp. with an initial pressure of 140 lb. is ordinarily supposed to develop this power with an admission of about ¼ stroke; admission carried to ⅓ stroke would increase the power to about 120 i.hp.

It is quite different with an internal-combustion engine, which will give its best combined thermal and mechanical efficiencies in the neighborhood of 90 to 95 per cent. of its maximum power. It is this consideration, which means economy in fuel consumption, that is responsible for the overrating of internal-combustion engines and has led many makers to adopt the wrong method of overtaxing their engines despite the important consideration of reliable working.

Diesel Engine Rating

A Diesel motor, which is not an explosion engine and does not depend for the quality of its fuel upon external devices like a producer, is much less subject to troubles caused through outside influences, yet when the Diesel came into practical use it was agreed among the European manufacturers ten years ago that the rating should allow for 20 per cent. overload—in other words, that the rating of a Diesel should involve constant working at the specified power and be such that it should stand an overload of 20 per cent. for about half an hour.

With a definite quality of fuel oil, the power specified is usually obtained with a mean effective pressure of 95 to 100 lb. per sq.in. for maximum constant working, while the momentary overload corresponds to 115 to 120 lb.

Regarding the so-called semi-Diesels, which might better be classified under "hot-bulb" engines, the European makers of good standing who started this construction of either the two-stroke-cycle or of the four-stroke-cycle types have also adopted a fair margin in the power, the better makes allowing from 15 to 20 per cent. for momentary overload.

On the other hand, to avoid future misunderstanding, manufacturers of Diesel and hot-bulb engines should warn their clients of the trouble that is likely to occur with oil engines running at light loads. It should be stated frankly to the buyers of heavy-oil engines that running even for a short period, several times a day, under one-fourth or even one-third of the rated load, is detrimental to the complete combustion of the fuel. This may result in carbon deposits on the piston and in the combustion chamber and interfere with the good working of the sprayer and the tightness of the valves. If the trouble does not show at once, it will become evident after a while, when the exhaust pipes and silencers will become clogged with carbon and half-consumed oil, making a very hard coating on the metallic surfaces. This drawback cannot be avoided altogether by regulation of the sprayer and of the water circulation, but it can be reduced by allowing the engine to run hotter when under light load. Moreover, this trouble is much more likely to develop when running on oils of a lower flashpoint or of a higher viscosity. Therefore, the most unsatisfactory oil to work with on light load is the tar oil.

When dealing with marine engines, either of the Diesel or of the hot-bulb type, the need for a fair margin in the power is even of greater importance. Marine engines, much more than stationary ones, are subjected to overloads beyond the control of the attendant. Overheating of these engines is the main cause of trouble that hampers their safe working and their power output. The heating of the cylinder castings and pistons after long uninterrupted work for several days is so serious that there seems to be a marked tendency in favor of the adoption of the four-stroke-cycle type.

A margin of 25 to 30 per cent. in power seems to be a figure allowed by some of the reputable marine oil engineers, especially for seagoing vessels.

If the manufacturers of Diesel engines are to be held to exacting conditions as to reliable working, the users, on the other hand, should employ the fuel that practice has shown to give the most satisfactory results. This fuel should answer the following specifications:

REQUIREMENTS FOR OIL USED IN DIESEL ENGINES

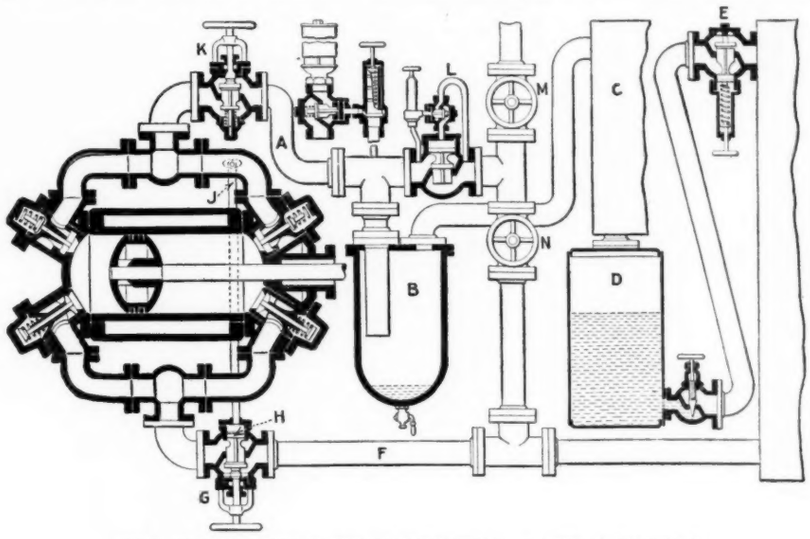
Free from solid material.
"Lower" calorific value not below 18,000 B.t.u.
Flashpoint not below 150 and not above 285 deg. F.
Boiling analysis will show 60 per cent. distilling until 670 deg. F. at least, and 95 per cent. at 750 deg. F. at least.
Ash not above 0.05 per cent.
Free sulphuric acid not above 0.3 per cent.
Water not above 0.5 per cent.
Viscosity at 120 deg. F., from 7 to 8 Engler; at 175 deg., 4.5 at most.
Specific gravity varying according to degree of refinement, but generally between 0.75 and 0.92.

With respect to the flashpoint, it has been demonstrated that the lower limit under certain conditions may be 70 deg. F. instead of 150. Concerning the amount of sulphur, it would not be objectionable below 2.5 per cent. The same allowance exists for the amount of asphaltum as long as the viscosity remains within the limits specified.

Converting Feet Head (H) into Pounds Pressure (P) is accomplished in the same manner for steam or other gas as for fluids—that is, by the use, as a multiplier, of a constant proportional to the specific gravity, or weight per cubic foot, of the gas or fluid. The common constant for water is 0.434, or H (feet head) × 0.434 (constant) = P (pressure per square inch). This constant is obtained by dividing the weight of a cubic foot of the fluid or gas by 144. Example: The weight of water per cubic foot = 62.5 ÷ 144 = 0.434, the constant in this case. A cubic foot contains 1,728 cu.in., equal to a column 1 sq.in. sectional area and 1,728 in., or 144 ft., high, so that the weight of 1 cu.ft. rests on a section 1 sq.in.; therefore the pressure on the 1 sq.in. is the weight of 1 cu.ft., or of a column 1 sq.in. cross-section and 144 ft. high, and the pressure per foot height is the weight per cubic foot divided by 144. The total feet (H) in a given case, therefore, multiplied by the constant (D, density) so obtained, for the given fluid or gas, gives the total pressure per square inch, or $P = \frac{H \times D}{144}$.

The Hennebohle Refrigeration Safety Device

Most ammonia accidents are brought about by over-pressure and the breaking of some line or vessel containing ammonia. The devices described herein are to prevent serious loss of ammonia to the atmosphere in case of breakage, to provide a safe relief for excessive pressure and to give warning that such excessive pressure exists.



THE HENNEBOHLE REFRIGERATION SAFETY SYSTEM

Referring to the drawing, the compressor is arranged to discharge through pipe *A* to a separator *B*, and then to the condenser *C*. The liquefied ammonia flows from the condenser down into the storage tank, or drum *D*. This tank has a liquid line going to the cooler and an expansion valve is connected in at the tank. In the liquid line to the cooler is a pressure-reducing valve *E* for delivering ammonia at uniform pressure to the evaporating coils. This valve is not necessarily a part of the safety system.

To prevent the escape of gas from the high-pressure side of the system, a stop-and-check valve *K* is provided at the discharge side of the machine, the disk of which is normally held open by the discharge pressure. Any break in the discharge side of the system producing a reduction in pressure will cause the valve to close. A reduction in pressure due to such accident is used to cut off the flow of gas through the suction main *F* by causing the operation of the stop-and-check valve G. This valve has a piston *H* with a flexible oil and ammonia packing cup, which is inclosed in a cylinder open to the discharge pressure through the pipe *J*. A reduction in pressure on the discharge side of the compressor or in the system between the compressor and the check valve *K* will enable the pressure on the suction side to overcome that on the piston *H*, closing valve *G*.

In the discharge line is a relief valve *L*, which, in case of over-pressure, will discharge to the atmosphere through valve *M* or into the suction main through the valve *N*. Connected into the discharge line is a whistle using steam or air which will blow at any predetermined pressure to warn the operator when the head pressure is getting too high. F. Hennebohle, South Chicago, Ill., sells the system.

Erecting a Steel Stack

By Loren L. Hebberd

About two years ago a large guyed steel stack was erected at the Wisconsin State Prison at Waupun. It was 54 in. diameter and 140 ft. high, the bottom half made of No. 8 gage sheets and the top half of No. 10 gage. The contractor shipped the stack in three sections intending to rivet them together on the ground and lift the stack in one piece with a gin pole, but was unable to get a large enough gin pile in the neighborhood and finally defaulted on his contract.

The stack was erected by the chief engineer of the plant in the following manner: The three sections were cut up into still shorter lengths by knocking out the rivets, and these lengths were then hoisted into place and riveted on successively. A large double A-frame which was clamped around the stack was used as a scaffold and also to hoist up the sections, and as each section was riveted in place the frame was raised to handle the next one. Thus the work proceeded very much like a fireman climbing a building with a scaling ladder. The A-frame in position is shown in Fig. 1. This frame had to be large and heavy and weighed 2,600 lb. The two men on the platform furnish a good means of comparison as to size.

In lowering the frame after the stack was completed, one of the men paid out his rope too fast, and as the frame was rather topheavy, it overbalanced and tipped over to the position shown in Fig. 2. Fortunately no one was on the platform at the time.

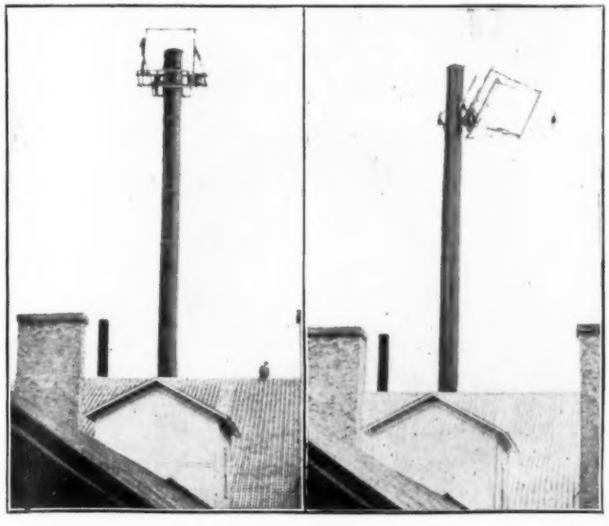


FIG. 1. SCAFFOLD IN WORKING POSITION

FIG. 2. SLIGHT ACCIDENT IN LOWERING

It is remarkable that although the stack had not been guyed at the time of the accident, it stood the strain of the heavy mass and was not damaged except for a small dent, which was easily hammered out.

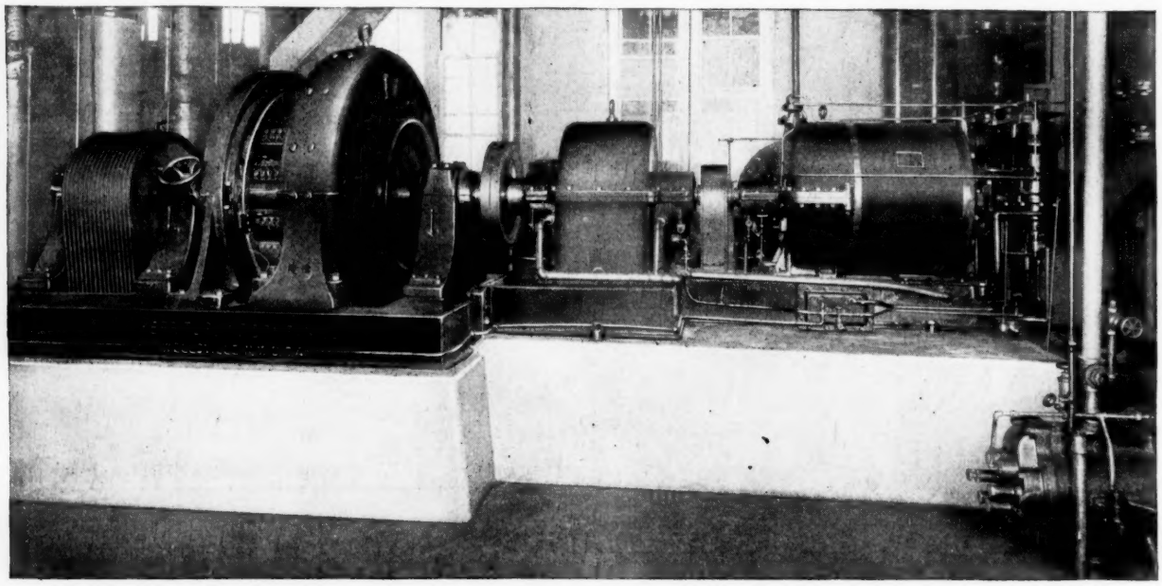
Mixed-Pressure Turbine in the Christian Moerlein Brewery

By John Arff*

It had been known for some time by the officials of the Christian Moerlein brewery in Cincinnati, Ohio, that the power plant was not up to the desired efficiency, and how to improve it most effectively with the least expenditure became a vital question. The steam pressure on six of the water-tube boilers was reduced by the inspector to such an extent that they became practically valueless for the future operation of the plant. If the steam consumption could not be reduced considerably, these boilers would have to be replaced by new ones.

A consulting engineer[1] was called in conference, and it was decided to reduce the steam consumption of the plant by installing a mixed-pressure steam turbine, shown in the accompanying illustration together with a condensing outfit and the necessary cooling tower. It was also decided to replace 20 ordinary direct-acting steam pumps and 3 low-grade air compressors by highly efficient direct-motor-driven centrifugal pumps and one high-grade motor-driven air compressor. Before this installation was made, the steam boilers had to supply the following machinery: One 300-ton refrigerating machine driven by a tandem compound noncondensing Corliss engine; one 220-ton refrigerating machine driven by a cross-compound noncondensing Corliss engine; three 100-ton refrigerating machines, each driven by a simple Corliss engine; one 200-kw., two 125-kw. and one 65-kw. 125-volt. d.-c. generators, each direct-connected to a high-speed engine; twenty direct-acting steam pumps of various sizes, some very large and quite a number of them located in the refrigerated rooms; three steam-driven air compressors; and the necessary live steam for boiling and heating purposes.

To furnish the steam for the apparatus, from 8 to 10 large water-tube boilers were necessary in the summer and from 6 to 7 in the winter. So to make an appreciable reduction in the steam consumption, a mixed-pressure turbine was installed which could be driven by exhaust steam furnished by two or three steam-driven refrigerating machines. The turbine using this exhaust steam could supply all the electric power and light and operate pumps. The engines exhaust into a main exhaust line 160 ft. long, wherein a back pressure of 2 lb. is kept when the turbine is in operation. From the main exhaust line several branch lines lead to various parts of the plant to furnish exhaust steam for heating purposes. The surplus exhaust steam is utilized in the turbine, and there is sufficient left for this purpose during eight months in the year. A 15-in. wrought-iron pipe connects the inlet of the turbine with the main exhaust line. Before the steam reaches the turbine, it passes through a 4-ft. diameter by 9-ft. high oil separator and then through a flow valve, which maintains a fixed back pressure in the exhaust main, this valve being set ½ lb. lower in pressure than the main back-pressure valve. The flow valve prevents the reduction of the exhaust pressure below that of the atmosphere, thus obviating leakage of air.



THE 650-HP. KERR MIXED-PRESSURE TURBINE IN THE CHRISTIAN MOERLEIN BREWERY

The turbine is of the horizontal shaft type, of 650-hp. normal capacity, operating at 3,600 r.p.m., driving through a 3,600-600 r.p.m. herringbone reducing gear both a 300-kw. 125-volt. d.-c. generator and a 200-hp. rope sheave, mounted on the shaft extension of the generator. This rope transmission drives a countershaft mounted in the basement located below the turbine, and the countershaft drives a 1,600-gal. per min. centrifugal circulating water pump for the steam condenser, a 1,400-gal. per min. ammonia-condenser circulating water pump, a two-stage

*Superintendent of Power.
[1]Otto Luhr, Chicago.

turbo-hotwell pump, and a rotary dry-vacuum pump. In this basement is also mounted the steam condenser.

The rope-drive arrangement is convenient, as it combines the driving of the condensing outfit directly with the turbine—that is, when the latter is started, the condensing outfit starts with it, and the reverse is the case when stopping.

It requires about 30 sec. to bring the turbine up to speed. It is designed on the Rateau principle, the steam being expanded through seven stages. Special nozzles are provided for high-pressure steam, the latter being automatically supplied through an auxiliary valve opened by the governor in case of deficiency in exhaust steam. The function of the special nozzles is to expand the high-pressure steam down to the exhaust-steam pressure in the first stage of the turbine. The governor is of the spring-loaded centrifugal type, consisting of spherical weights driven through a worm gear on the turbine shaft and acting upon the steam-valve stem through a relay pilot valve. A lever in connection with a collar on the governor spindle operates the relay-plunger stem, admitting oil under 30-lb. pressure to the upper or lower side of the steam-valve stem piston. The high- and low-pressure valves are operated by the same valve stem. The latter is rigid to the stem, while the former is opened by a collar on the stem after the low-pressure steam valve has reached its full opening. While the governor operates the relay plunger only, the latter regulating the admission and release of the oil for the steam-valve stem piston, the speed regulation is very close and accurate.

An emergency governor independent of the main governor shuts the turbine down when it reaches a speed of about 10 per cent. above normal by closing the high-pressure steam valve automatically and breaking the vacuum. A rotary pump on the lower end of the governor spindle supplies the oil from the reservoir in the turbine base to the relay-plunger case under about 30 lb. pressure and to the bearings and gear casing under 3 lb.. The returning oil is cooled in the reservoir by water passing through a set of coils. The glands at both ends of the shaft are sealed by steam against inleakage of air.

The steam consumption of this turbine is 31 lb. per hp.-hr. at full load and 38 lb. per hp.-hr. at half-load, with 2 lb. initial pressure and 27-in. vacuum. If the vacuum drops to 26 in., the steam consumption increases 7 per cent. at full load and 13.5 per cent. at half-load. It is seen from this that the vacuum plays an important rôle in a low-pressure steam turbine, but since we have a cooling tower from which the available water is higher in temperature in summer and lower in winter, such prevailing conditions are to our advantage—because we have more exhaust steam in summer and less in winter, so that the difference in vacuum is equalized by the difference in exhaust steam available. It is perhaps needless to say that the saving in steam consumption is equal to what the 20 steam pumps, the 3 air compressors and the dynamo engines required. This saving is of course due to the combined installation of the steam turbine and the electrically driven pumps, etc. The condenser water is all pumped through the feed-water heater and into the boilers, and since it is free from scale-forming ingredients a whole lot of trouble and labor is saved. Quite a bit of water is also saved on account of regaining most of the feed water, to say nothing of the lubricating oil, packing, repairs and attention steam pumps require over motor-driven centrifugal pumps.

The turbine was furnished by the Kerr Steam Turbine Co.

Burning No. 3 Buckwheat Coal on a Coxe Stoker

By B. B. Hood*

SYNOPSIS—The stoker has three air ducts running transversely to and beneath the fuel bed, each duct carrying air at a different pressure. A thin fire with high grate speed gives best results. The performances of six eight-hour tests are tabulated.

Considerable attention is paid to the use of the cheaper grades of fuel. The smaller sizes of anthracite, at one time discarded as being valueless, are now reclaimed and sold. No. 3 buckwheat is anthracite that will pass through a $\frac{3}{16}$-in. and not through a $\frac{3}{32}$-in. round hole. It contains from 3 to 6 per cent. volatile matter and 15 to 25 per cent. ash. As usually weighed when sold, it contains about 10 per cent. moisture, and unless steps are taken to dry it, it will contain nearly this amount when fired.

I have burned this grade on a mechanical stoker[1] and how it is done should interest other engineers. The stoker has a traveling grate made of horizontal bars held by two endless chains, which are guided and driven by front and rear sprocket wheels. The chains slide upon guides so that there is no sag between sprockets. The bars are fitted with small castings, making each of them similar to a piano keyboard. The grate surface therefore consists of a large number of "keys" between which the air for combustion finds passages consisting of small notches in the sides of the keys (see the illustration). The air openings total about 9 per cent. of the grate surface. The power required to drive the stoker is about 1½ hp. at the motor switch; worm reduction gears are used.

In the installation of which I speak, the space between the sprocket wheels is partitioned into several air ducts in which there is forced-draft air pressure. Coal is fed through a suitable chute to the front end of the grate and is ignited from the hot brick arches above. The coal is ignited on top, and as the grate travels along combustion continues downward through the coal bed. Unless excessive air for good operation is forced through the first air duct, the top coal will not completely burn

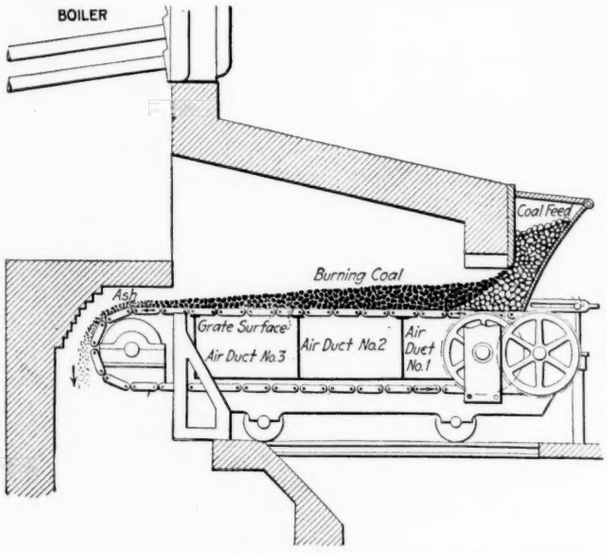
*Boiler-room superintendent, United States Metals Refining Co., Chrome, N. J.

[1]The Coxe stoker.

until the whole bed has been ignited. The bottom coal burns first, the ash gradually rising until it appears on top. This should take place over the first half of the third duct. The ash falls by gravity from the grate at the rear end of the stoker. The depth of coal can be regulated by a vertical gate at the base of the coal chute. The speed of the grate can be varied to suit conditions.

To obtain the best results it is essential that the air pressures in the ducts be carefully regulated. In the first duct the pressure carried depends upon the depth of coal and its stickiness when ignited. With the conditions that I have met, a pressure of about 1½ in. of water with a coal depth of 5 in. gives the best results.

If ¾-in. pressure or lower is carried, ignition is likely to be lost at the higher (15 ft. or over per hour) grate speeds. If from ¾ to 1¼ in. is carried, ignition will be sustained, but the coal will form a sticky or compact mass which is hard to burn properly and an excessive amount of CO will be formed. If 1½-in. pressure is carried, a small amount of excess air is blown through a large number of openings in the incandescent coal bed.



SECTION OF FURNACE WITH COXE HARD-COAL STOKER

This makes a white-hot fire and insures a minimum of CO. The difference in appearance between this fire and one with a lower pressure is the same as that between a tungsten light and the usual carbon light. It is impossible to furnish sufficient air for complete combustion unless it is blown through these small blow-holes. Other types of stokers for long flaming coals obtain this result by introducing the proper amount of air above the fire surface. If 1¾-in. pressure is carried, the white spots will soon turn dark, indicating that enough air is being blown through to completely burn the top coal before the bottom has burned or even ignited. The range in draft pressure, between running the front end as a gas producer and blowing black spots in it, is only about ½ in. of water.

In the second air duct a lower pressure is carried, usually just enough to keep the ash from appearing on top before it gets over the third duct. This depends upon the grate speed and upon how much combustion took place over the first duct, which in turn will depend upon the volatile matter and ash in the coal. The third duct has barely enough pressure to keep live coal from going over with the ash. To burn the ash clean of coal requires a large amount of excess air blown through the grate, which means a loss in the boiler efficiency. This is greater than the loss of the coal in the ash, but there is an economic balance to be struck here. A coal that will clinker moderately gives better results than one that will not form clinkers, as they tend to force the air through the unburned coal instead of allowing it to be blown through the ash. The coal that lies next to the grate surface does not get ignited, owing to its cold surroundings. If wet air, such as that containing exhaust steam, is furnished, the thickness of the unignited coal bed is greater than when a dry blast is furnished.

To cut down the amount of coal lost, thicker fires with slower grate speeds were tried. Higher air pressures were required, which caused blow-holes in the rear end of the fire and sometimes in the center. When a blow-hole once started, the fuel bed would be torn up all around it by the higher blast pressure. If lower pressures were carried, the fuel bed acted as a gas producer and any amount of excess air blown through the rear end of the grate would not properly combine with the excess CO produced. More coal can be burned when using a thinner bed and a higher grate speed than with a thick bed and slow speed. Consequently, when pushing the boiler the former operation is demanded.

When the demand for steam is variable, the depth of fire should be kept constant and the variation obtained by changing the grate speed and air pressures in the second and third ducts. The air pressure in the first duct should not be changed. Immediate changes in load can thus be effected.

An installation consisting of a B. & W. boiler with 3,950 sq.ft. of heating surface (400 hp.), an individual economizer with 2,000 sq.ft. of heating surface and a stoker with 102 sq.ft. of effective grate surface gave the following results from six 8-hr. tests:

Test No.	1	2	3	4	5	6
Boiler horsepower developed	545	591	650	741	837	929
Equivalent evap. from and at 212 deg. per pound dry coal, lb	9.82	9.46	9.23	8.64	8.37	8.06
Grate speed, ft. per hr	10.5	11.8	15.1	17.4	18.3	20.0
Depth of coal fired, in.	5.00	5.00	4.62	4.87	5.25	5.67
Pound dry coal fired per sq.ft. of grate per hr*	18.8	21.1	23.7	29.0	33.8	39.0
Average CO_2 in flue gas, per cent	11.1	11.1	11.3	13.2	12.2	13.2
Ash in coal, per cent	19.0	17.5	15.1	18.4	19.8	17.4
Combustible in refuse, per cent	28.5	34.4	20.1	27.5	38.9	48.4
Refuse of dry coal fired, per cent.*	36.1	34.2	21.2	27.7	31.0	38.9
Number of days boiler was in service since last internal cleaning	4	5	45	52	3	39

* Does not include flue dust.

A stack draft of ¾ in. and a forced-draft pressure up to 2½ in. of water were available. Atmospheric pressure was carried just above the fire. Feed water was 60 deg. F. and steam pressure 145 lb. The economizer produced 7 per cent. of the total horsepower developed.

Experiments with a Steady Flow of Steam in Pipes of uniform diameter show that the drop in pressure is influenced by the length of the pipe, its diameter, the nature of its interior surface, the velocity, density and quality of the steam, its expansion and heat lost by radiation and the effect of gravity. Attempts to include all these factors in determining the proper size of pipe have led to unwieldy and little-used formulas. All such formulas are based upon the hydraulic equation for the loss of head, or drop in pressure, due to friction when water, steam or gas of any kind flows through a straight pipe, namely, $H = f \frac{v^2}{2g} \times \frac{4L}{d}$, in which H = loss of head measured in ft.; v = velocity of fluid in ft. per sec.; L = length of pipe in ft.; d = diameter of pipe in ft.; g = acceleration of gravity = 32.16; f = coefficient of friction.

Editorials

Selecting an Engine for the Power Plant

Operating engineers often find the duty of selecting an engine suited to the requirements of the plant a perplexing problem. It is comparatively easy to choose when only the question of general type is involved—whether it shall be a four-valve engine with a positive or a releasing style of gear, a single-valve automatic or a throttling engine, a simple engine or a compound. But beyond this the range of selection is so wide that unless a bias for an engine bearing some particular trade name narrows the engineer's view, there will be much to confuse him when he compares the leading features of various makes. There are, however, certain items of design that should supply an undeviating line of comparison in this regard.

When an engineer essays the problem of determining what make of engine it is best to buy, he should first of all dismiss the idea that the greatest durability and strength dwell in what appear to be the most massive structures. The fact that an engine of one make has a considerable preponderance of weight over one of another make does not necessarily argue that it is more durable and stable than its rival. Generously proportioned beds and frames count for naught if there is a poverty of material in the bearings and moving gear. As it was with the deacon's famous one-horse shay, so it is with the modern steam engine—adequate weight and strength of material symmetrically distributed throughout the whole fabric count mostly in holding the engine together against the wear and tear of time.

If the choice lies among different makes of four-valve engines, with valves of the Corliss type, the extent of bearing surface which the valves have where they overlap the ends of the ports is an item demanding careful attention, as is also the size of the valve stems and their depth of bearing surface in the bonnets. These of course should be ample, but still there is a limit that can be easily exceeded to the detriment of economy. This is especially true of the wearing surfaces of the valves. Excessively large diameters, due to the high peripheral speed, add to the friction load on the engine, while cutting and scoring of the valves and seats and difficulty of lubrication are apt to attend the opposite extreme. The same strictures apply in the case of the stems—extra friction if their bearing surface is too large in diameter, and rapid wear, inviting instability and transmitting its effect to the whole valve mechanism, if the surface is too small.

If the single-valve high-speed automatic engine is under consideration, there is little to choose between the piston valve and the flat balanced valve, when both represent the same degree of excellence in their respective styles of design. A well-proportioned flat valve, designed to automatically take up the wear, will continue steam-tight indefinitely if given due attention in the matter of lubrication. The piston valve, generally considered, requires more frequent repair to keep it steam-tight, but the repairs are easily made; while in the case of the flat valve, once it begins to leak, restoring it to a steam-tight condition is a difficult job calling for high mechanical skill. At one time the cylinder clearance was generally greater with a piston valve than with a flat valve, but in uptodate construction this does not apply.

All comparisons of running speeds hinge upon the fact that practically the same conditions prevail as regards friction and stability when the same ratio of speed to bearing surface traveled over exists between two engines, regardless of the rates of speed, the lubrication being equally effective. That is to say, if one engine makes two hundred revolutions per minute and another two hundred and fifty, the latter should have one-quarter more rubbing surface in the principal bearings (the piston, valves, guides, main journals, crank and crosshead pins) than the former, to hold the friction to the same figure with the same weight. A lighter flywheel at the higher speed would of course influence the relative proportions of the bearings.

These are some of the salient points that should be considered in addition to steam economy, relative cost and the character of the service required.

An Important Application of the Phase Converter

In the discovery of almost every important principle there are what may be termed other residuum principles. This is exemplified in the discovery by Ferraris in 1888 that a rotating magnetic field could be produced by two or more alternating currents displaced in phase from one another, which made possible the polyphase induction motor. As a residuum of the application of this principle to the polyphase induction motor, other principles became manifest, namely: The principle of the induction generator, the frequency changer and phase converter. The first two have been utilized considerably. A notable example of an induction-generator installation is found in the Interborough Rapid Transit Co.'s Fifty-Ninth St. power house, New York, where five 7,500-kv.-a. units of this type have been installed. Several large frequency changer sets have been installed, for tying alternating-current systems together of different frequencies and for varying the speed of large induction motors. However, it remained until very recently for any important use to be made of the phase-changing characteristic of the induction motor.

On another page of this issue will be found an article describing the principles of the phase converter and its application to the electric locomotives used on a mountainous division of the Norfolk & Western Railroad. Phase converters on these locomotives made it possible to combine high-voltage single-phase transmission with the rugged construction of the polyphase induction motor, regenerative braking and simplicity of control. It is gratifying to see this principle used on so large and important an installation, especially when the application

has proved so successful, and it may well be proclaimed as another step forward in the generation, transmission, distribution and application of electric power.

Chimney "Stacks"

The use of the word stack, which in itself seems to infer a plurality, for a single shaft like the smoke-stack of a factory or a steamboat, is so inconsistent that many expressions of wonder are heard as to how such use came about.

In ordinary house and office buildings where numerous fires were maintained, the flues from various fireplaces and furnace connections were brought together into a "stack" and combined in one structure protruding above the roof. This chimney was really a stack of flues, but the use of the word stack soon came to be loosely applied to everything from the stubby smoke-pipe of a locomotive to the immense column of masonry which carries away the products of combustion from the boiler house of a great central station. Efforts to control the choice of the word stack or chimney by the size of the object under description or the material from which it is built are funnier than some of the uses of the word itself.

Another word usage with which we should like to quarrel is that of the term specific gravity, which should signify the particular, individual gravity or weight of the substance in question, the weight per unit of volume of that substance itself, not the ratio of its weight to the weight of an equal volume of some other substance, usually water for liquids and air for gases. The term "specific" is here used to signify relative, for which in ordinary cases it is practically the antithesis.

Heat in Exhaust Steam

In a recent paper in the "Colorado School of Mines Quarterly," R. S. Hawley, professor of mechanical engineering at that institute, quotes and accepts a statement of C. L. Hubbard that "we may assume in average practice that eighty per cent. of the steam supplied to an engine is discharged in the form of steam at a lower pressure. The remaining twenty per cent. is partly converted into work and partly lost through cylinder condensation."

The heat put into an engine must come out of it in one of three ways—by radiation, as work, or in the exhaust. That lost by radiation is the least important and, with well-protected cylinders, will be a small proportion of the heat supplied at normal load. The heat converted into work equals 2,546.5 B.t.u. per indicated horsepower-hour, so that this item can be determined with a precision depending upon one's knowledge of the amount of work done. The rest will be in the exhaust. Cylinder condensation has nothing to do with it, for all the heat given up to the cylinder while the initial charge is being condensed in warming the containing walls so that it can live as steam against them is abstracted during the expansion and exhaust strokes. Otherwise it would accumulate until the condensation ceased. It may be that the "cylinder condensation" quoted meant condensation due to radiation from the cylinder and conduction to the frame, but that is not what is ordinarily understood by the term.

Semi-Standard Equipment

Engineers with initiative almost inherently dislike "catalog designing" in plant extensions. A man with broad operating experience learns the weak points of equipment, and when his advice is sought in connection with a change of apparatus or when an addition to the plant is contemplated, he naturally leans toward securing an original solution of the problem. That is, he swings away from standard practice if he can see a justified opportunity to specify machinery or apparatus arrangements differing from the ordinary, it being clear in his own mind that cut-and-dried methods are less adapted.

Between slavish adherence to the commonplace and radicalism in design or selection lies a happy medium of practice based on the use of semi-standard equipment. Usually this is by all odds the best course. An example may be cited in the provision of outdoor substation equipment at a plant that is to be tied into a transmission network where moderate voltages, say under 33,000, are involved. The engineer with initiative who lays out such apparatus is tempted to design an entirely new structure to carry the necessary insulators, transformers, etc., doubtless using standard cross-sections of steel, but overlooking the fitness of commercial outdoor substation material for his purpose. Such equipment, which has been developed by the modern manufacturer with great care to meet the exacting demands of moderate high-tension distribution, should be at least considered in work of this character, so that its cost can be compared with that of performing the task on a purely original basis of design. The lengths of structural members available in the standard sets for the simpler outdoor substation work may not be best suited to the spacing of wires, switch and transformer arrangements required at the local plant concerned, but by slight changes in these, perhaps by the choice of other combinations of angle irons and plates used by the manufacturers of such material, the equipment can be adopted in a semi-standard form which may result in the lowest cost solution of the problem in hand. There are many vagaries of design to be seen in this field of tying a station into an outside system, and it is worth while to study carefully the possible savings of semi-standard equipment.

One more example may be taken from inside the station. A motor may be required to drive a conveyor at a certain speed, with perhaps a range of control as to revolutions per minute not readily attainable in standard sizes nearest the power output demanded. Shall the manufacturers be asked to design a new motor, or shall the engineer endeavor to guide the selection along the line of utilizing parts of existing standard motor designs, or perhaps changing the gearing or belting of the standard conveyor layout to permit the use of a less costly motor unit?

Circumstances will determine in any given case, but in seeking the benefits of standard products, the wise engineer also tries to find out the cost of minor modifications in it when the gain from a more accurate (semi-standard) installation looks worth while.

Mr. Poole, in his letter on "Cylinder Oils," page 885, mentions some more instances of "Unfulfilled Guarantees." This time again, it was a municipality that found out the failure to meet pretensions.

Correspondence

Superheating Exhaust Steam

Seeing the subject of heating by live or exhaust steam discussed at great length in *Power,* I would like to suggest an economical means of heating by exhaust steam, but am not in a position myself to give it a trial. I should like others to give their opinion of the practical working of the plan, assuming a plant working at 100 lb. or more steam pressure at the boilers and a back pressure of from 5 to 10 lb. and the waste gases entering the smoke stack at 500 deg. F.

My idea is to superheat the exhaust and raise the temperature to approximately that of the live steam or even higher, and by so doing send out steam that contains more heat units so that less will be required, and if possible cut down the back pressure. The same principle would apply and effect greater economy by superheating the exhaust steam to a low-pressure turbine.

Calgary, Alta., Canada. A. Bradshaw.

Cylinder Oil Viscosity

F. L. Fairbanks' letter on pages 701-3 in the issue of May 16 is the most practical and intelligent discussion of the problem of cylinder lubrication that I have seen in print in many years; it should be framed and hung in the engine room of every stationary plant in the country.

The statement to the effect that the viscosity of a cylinder oil bears no relation to its lubricating quality has been made many times—mostly by persons interested in the exploitation of cylinder lubricants composed largely of animal oils, which lose viscosity rapidly with increasing temperature. That statement is as misleading as the ordinary viscosity test, to which it might be applied with some degree of justification.

The viscosity of a cylinder oil, determined at the proper temperature and considered in the light of the specific gravity, volatility and purity of the oil, is the only criterion of its lubricating value short of an experimental determination in the engine itself, which is nearly always impracticable. The "staying" quality of a cylinder oil decreases with increasing specific gravity, unless the inherent viscosity also increases; the explanation of this fact is tedious, and it is unnecessary to burden this letter with it; any experienced oil chemist understands it. By "inherent" viscosity is meant viscosity not due to adulterants or "filler." The lubricating value is also lower for a higher degree of volatility than the reverse.

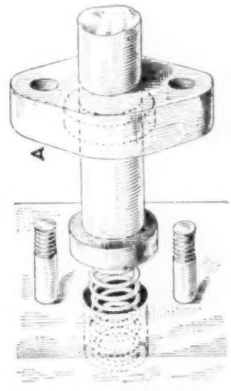
Given an evaporation of not over 5 per cent. in eight hours at a constant temperature of 400 deg. F., and freedom from adulterants and "filler," the ratio $\frac{\sqrt{\text{viscosity}}}{\text{sp. gr.}}$ is an excellent guide as to the lubricating quality of a cylinder oil. The specific gravity here meant is the ratio of the weight of the oil to that of water at 60 deg. F.—not the hydrometer-scale value. The viscosity of course should be taken at the maximum temperature that occurs in the engine cylinder to be lubricated.

Some reader interested in the oil business may possibly take exception to the intimation that cylinder oils are adulterated or "filler"-treated. To any such reader I beg leave to state that seven samples of cylinder oil submitted with bids last year for the annual contract of the City of Atlanta were found to contain "oil pulp" or oleate of aluminum to such an extent as to cause them to be thrown out of consideration. The viscosities were alluringly high, of course. Cecil P. Poole,

Atlanta, Ga. City Mechanical Engineer.

Stopping Knock in Valve Motion

I am in charge of a 16x18-in. high-speed engine, having a Sweet balanced valve which receives its motion through a rocker-arm that causes the valve rod to oscillate slightly. The rod is attached to the valve by two studs and a loose collar, which is recessed to fit over a fixed collar or head on the end of the rod, forming a flexible joint. But the least clearance to allow the necessary oscillating movement caused a very disagreeable noise. To remedy this I drilled a 1-in. hole 1¼ in. deep in the end of the valve opposite the center of the rod and inserted a coil spring of ⅛-in. steel long enough so that it would be compressed about ¼ in. when the collar *A* was drawn tight, the recess in this collar being nearly $^1/_{64}$ in. deeper than the thickness of the head on the valve rod. This proved very satisfactory. The size and tension of the spring must be proportional to the weight of the valve. T. O. Vickers.



APPLICATION OF SPRING

Trenton, N. J.

What Was the Trouble with the Compressor?

An 8-ton ammonia compressor, piped as usual, upon being started gave a noticeable pound at the crosshead while passing the crank-end center. The back pressure went up to 30 lb. (gage), which was about as usual, but the head pressure, instead of going to 170, only went to 155 lb. and soon dropped to 140 lb., the back pressure still remaining at 30 lb. The head-pressure gage pointer gave only one vibration each revolution. As the machine began to frost over the head-end conditions were normal, while the crank end frosted over heavily—the discharge valve and connections being only slightly warm, while the main discharge line and head-end discharge valve and connections were as hot as usual. Only one suction valve working could be heard, accompanied by a faint blowing

sound, but as the compressor runs at 70 r.p.m., it was impossible to determine at which end the sound occurred.

After a couple of hours the operator tried the valve on the equalizer pipe between the suction line and the oil reservoir, which is usually kept one-half turn open. Upon closing this he heard the other suction valve start to work, and he opened the valve again. The valve stopped working, then upon closing the valve to one-quarter turn the machine began to operate normally—the frost thawed off the crank-end head and part of the suction-valve bonnet. The discharge valve and connection warmed up to the temperature of the head end, and within ten minutes the head pressure went up to 155 lb. and the back pressure dropped to 24 lb.

If any of the readers of *Power* have had a similar experience or can give any explanation of this trouble I would be glad to hear from them.

Del Monte, Calif. A. C. McHugh.

Fuel Injection Valves

What should be the fundamental feature of the oil-spraying valve? Unquestionably the perfect fuel valve should be able to handle all sorts of fuel without such adjustment as is beyond the ability of the average engine operator. The valves now in use may be divided broadly into two classes:

1. Those which deliver the oil into a "fuel receiving chamber" containing such obstacles as will cause the oil, with the air pressure behind it, to be broken up into a fine spray as it enters the cylinder.

2. The other type is illustrated by the Hesselman valve. In this the fuel is forced into the air current in a steady stream by means of an unbalanced air pressure produced by the proportions of the passages.

In the first case the fuel can, under certain conditions, be fed with good results. In the second case conditions are much nearer ideal. The viscosity of the fuel plays a much more important part in the first case than in the second, but in both it is a great factor. In the second case it is evident that the fuel valve must be differently proportioned for a sluggishly flowing oil than for a freely flowing oil. Obviously, it is not wise to substitute different fuel valves for different oils. The solution would seem to lie in a double valve with separate air and oil seats. Time the valve on the air passage to open ahead of the one on the oil passage. In this way the fuel will be delivered into a spray of moving compressed air. By designing the junction of these two passages so that the oil will enter at practically right angles to the air current, there should be an ideal condition as regards atomization. The regulation would come from the length of time the two valves remained open.

In such a valve the only variable element is the pressure on the fuel. The air pressure would be fixed by the compression pressure of the engine and the particular cycle under which it was designed to operate. If a particularly heavy, sluggish fuel were to be used, a higher pressure could be used on the fuel line than with a lighter fuel. Also, since the fuel and air do not mingle till just at the instant of entrance into the cyinder, there is no limit to the maximum temperature of either. In other words, there would be no danger of ignition in the fuel valve before it was opened. This would allow much higher temperatures to be used in the fuel, which would insure better physical properties. This design of fuel valve would also allow much higher temperatures of injection air to be used. It has been pointed out that by increasing the temperature of the injection air from 60 to 580 deg. F., the saving in injection-air losses can be reduced one-half. This loss amounts to about 10 per cent. of the b.hp. of the main engine.

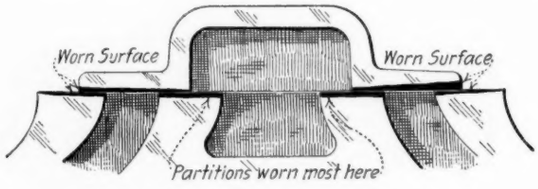
This proposed development in the fuel valve seems to be along lines sound thermodynamically and simple practically. The delicate proportionment of parts necessary in present valves will be done away with. In place of coaxing the action of the fuel, brute force will be applied to it, making its action absolutely positive and reliable. It is of course expected that the advantage of heating the fuel will not be ignored because of this condition. The oil engine has come to stay, and the sooner that every possible means of improvement is utilized the better for both builders and users.

Quincy, Mass. John F. Wentworth.

Valve and Seat Refaced with Cold Chisel and File

Away from the railway ten miles was a little job that needed attention. I was on my vacation in the cotton country, just from town, and as I had been employed in machine shops, power houses, etc., everybody looked upon me as an A-1 mechanic.

The owner of a cotton gin asked me to assist him a little on the cylinder of a 25- or 30-year old slide-valve,



WORN VALVE AND VALVE SEAT

side-crank 12x16-in. engine. The last time the engine had been run the demand for steam was so great that it kept three teams busy hauling wood about a mile, with 200 cords to start on. The boiler furnace had been burned out, and the fireman was ready to resign.

I found the cylinder in very good shape, only about 0.004 in. larger through the vertical line than the horizontal. The valve and seat, however, were badly worn, where indicated in the accompanying sketch. The nearest machine shop was 45 mi. distant, and as the engine was wanted badly, I decided to tackle the job with the best file I could get, an 8-in. fine-cut mill. This did not last long, and it was then sharpened to use as a scraper, which did very well. Some 16-in. crosscut coarse bastard files were ordered, but they did not arrive in time.

Using a cold chisel for cutting away the bulk of the metal of the valve and scraping with the file scraper and using the unworn side of the valve-stem guide for a surface plate, the valve was put in good shape. The chisel, file and a lot of muscle applied to the valve seat soon put it in proper condition. It required removing nearly 1/8 in. of metal at the highest points.

About seventy-five of the countrymen came to witness the assembling of the engine and crowded in to see it trammed and the valve set.

After three months' running I saw the owner, who stated that he was using only about one-third as much wood as he burned the year before.

Dumas, Miss. GROVER C. HOPKINS.

Rope Drive Versus Belt Drive

On page 669 in the issue of May 9 I noticed an article headed, "Some Rope vs. Belt Figures." The computation is undoubtedly carried out correctly on a basis of the rope drive running at 90 per cent. efficiency and the belt drive at 95 per cent.

I wish to inquire what type of rope drive is referred to and also what Mr. Wilson's authority is for the statement that a belt drive has a higher efficiency than a rope drive under *any* conditions. C. S. REEVES.

New York City.

Some Good Suggestions

Some time ago a contributor to *Power* said that some interesting power-plant topics were not enough discussed and that he would like to, or like to see someone, "start something." As I am more familiar with what I think we should have at home (Canada, western parts) than I am with the United States, I would advocate first, uniform boiler laws as regards construction and workmanship; not boilers that are made and supposed to be inspected by competent persons and, when coming into Alberta, found not up to the mark in workmanship. I must admit, however, that we are now getting better boilers than we did some six or eight years ago, both in workmanship and design. As it has been, and is yet, my luck to do some flue-creeping, I have found it impossible in several boilers to make a proper examination inside after they were cleaned, on account of not having enough room space between the tubes and shell; and I am not a big man. Not only uniform laws as regards designs, but supervising construction should be under inspectors who have a thorough knowledge of the theory and practice in boiler construction and know good workmanship when they see it. These inspectors should insist on plates being close-fitting, rivets and tube holes being fair; all seams inside the boiler should be calked—no leaking rivets and seams. I am not referring to imaginary cases that might happen, but to things that I have seen and observed on many occasions.

As there is now a greater tendency to carry pressures of over 100 lb., lap-joint boilers should be a thing of the past, and I am glad to read that some states of the Union are not, to say the least, in favor of them.

As to cast-iron fittings, certain valves intended for 125 or 150 lb. pressure are too light for continuous operation. Pressure governors on boiler-feed pumps are good, but often meet with objections from the fireman or operating engineer who has the bypass open. I have found that a relief valve on the feed-water line in the boiler room is as good a safeguard as can be had, but this valve must be set to the proper pressure above boiler pressure and should be sealed by the inspector, the same as the safety valves on the boilers, and tampering with it should be subject to the same penalties.

When exhaust steam is discharging into heaters or heating plants for buildings or kilns, back-pressure valves are generally used. The amount of damage done by exhaust steam in heaters and heating plants is surprising. The cause is often back-pressure valves of poor design or good back-pressure valves overloaded by zealous attendants, who could give pointers to the other clan that "did not know it was loaded." Therefore sealed safety valves should be placed on exhaust lines and tested pressure gages on exhaust pipes to indicate pressure. It is needless to advocate automatic nonreturn valves on each boiler, as their good uses are becoming well-known, but they must be attended to and kept in proper order.

But did it ever happen to you fellow engineers to have to go on top of the boilers to cut in or cut out one, or to close or open a valve, and find the ladder gone—borrowed for ten minutes? The only thing you could do was to get to that valve the best way you could, but get there quick. Why not have permanent ladders grouted in the floor and riveted to the iron structure supporting the boilers and have enough of them so that you do not have to get scalded if a joint is blown on the steam line between the ladder and yourself.

Proper walks on top of boilers save the insulation. These last two items do not cost much and have not yet been refused me by any manager or owner, no matter how close they were on expenses.

Another thing is a blowdown tank. This tank, when inside the building and where space is limited, should be designed to carry the same pressure as the boiler and have, extending above the roof, without valves, a vent pipe one-fourth larger in diameter than the waste pipe from the tank to the sewer, and the waste pipe should be at least twice the diameter of the blowoff of the boiler. When more than one boiler is connected to a tank, a check valve between the tank and the blowoff valves should be put in. This would reduce the possibility of blowing down a live boiler while there might be a man inside an open one who had forgotten to close the blowoff valve.

Another thing that used to make me feel much safer when inside a boiler was a piece of chain and a lock on the handle of the valves of the boiler I was in. Our boiler washer always removes the bonnet of the feedwater regulating valve to ascertain the condition of the disk and replaces it only when he is ready to fill the boiler; he maintains that this is the best way to prevent the water attendant from making the mistake of turning the water into the wrong boiler. I think he is right.

Nordegg, Alta., Canada. BENJAMIN J. RENDOV.

Groaning in Engine Cylinder

I would like to add something, which may be of interest, to the question and answer on page 671 of the May 9 issue of *Power*, entitled "Why Engine Requires More Cylinder Oil."

A 36x36-in. cylinder of an engine, running condensing, could not be kept from groaning regardless of the amount of cylinder oil fed. Indicator diagrams revealed that the valve gear was considerably deranged with the result that the exhaust did not begin until the piston had started on the next stroke, and the admission was very late. Furthermore, the distribution of steam for the head and crank end was badly equalized. After the valves and the eccentric had been set properly, the engine was started. The groaning had disappeared and is still absent.

This engine, I was told, had been groaning for years and also would not carry the load properly. After the valve setting the engine gave some excellent indicator diagrams and also proved to be far too large for the load it had to carry. WILLIAM SCHLIEMANN.

New York City.

Pointing Off Decimals with the Slide Rule

In your issue of Mar. 24, 1914, there appears an article dealing with the fixing of the decimal point in slide-rule calculations. For multiplication you give the rules:

When the first figure of the product is LESS than that of the factor having the greater first figure, then the number of integer places of the product equals the sum of the integer places in both of the factors.

When the figure of the product is GREATER than that of the factor having the greater first figure, then the number of integer places of the product equals the sum of the integer places in both of the factors minus one.

And for division:

When the first figure of the dividend is LESS than that of the divisor, then the number of integer places of the result is equal to the difference of the number of integer places in the dividend and divisor.

When the first figure of the dividend is GREATER than that of the divisor, then the number of integer places in the quotient is one greater than the difference of integer places in the dividend and divisor.

These rules do not seem complete, for they do not cover cases containing the unity factor and its decimal subdivisions, in which cases the first figure of the product or division will equal that of both factors. To apply your rules to these cases the wording of the first rule for both multiplication as well as division should be changed from "less than" to "not greater than." R. O. MULLER.

Hartford, Conn.

[Mr. Muller is right, but one would hardly use a slide rule or a calculating machine to multiply by unity or its decimal subdivisions.—Editor.]

Induction Motor Burned Out

While a polyphase induction motor is in continuous operation, one of its protecting fuses may blow without the condition being noticed. The fuses are installed on the running side of the compensator; therefore, since the connections of the starting side are in no way affected by the blowing of the fuse, if the load to be started is comparatively light, the rotor will attain almost synchronous speed on the starting side of the compensator, and when the compensator handle is thrown to the running side, the motor will continue to operate, but single-phase. Under this condition, however, the current per motor coil will be greater, because the rotor speed will decrease and the total current will increase until the energy input of the motor becomes about the same as it would be were the motor operating polyphase.

It must be borne in mind, however, that when the polyphase motor is operating as a single-phase machine, its torque is not as continuous, its synchronizing effort is not as strong and less connected load will be required to stall it than under polyphase conditions. Therefore, even if the machine does hold in at the time of starting, if too much load is imposed afterward, the rotor will be stalled and the motor thereby subjected to abnormal currents that are apt to burn it out unless a safety device operates to save it. Whether the abuse be due to the blowing of a fuse or whether it be due to repeatedly trying to start when there is an open-circuit in the starting circuit, the ultimate result will be the same for a given amount of abuse.

A large three-phase induction motor burned out, for reasons that were at first not evident. As the motor circuit included no fuses, the failure could not be attributed to the blowing of a fuse. On disassembling the motor for repairs, the rotor evidenced excessive heating over six well-defined areas that were 60 deg. removed from one another around the periphery of the end rings; this condition constituted undoubtable evidence of single-phase operation with the rotor standing still. On a four-pole motor the burnt areas would have been 90 deg. apart and on an eight-pole motor, 45 deg., the pitch of recurrence of the burned areas in each case being the same as the pitch of the stator poles.

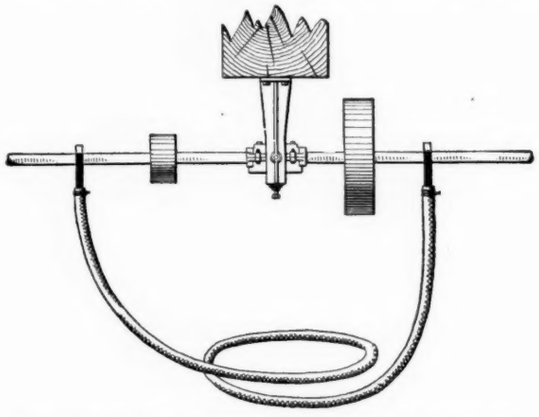
On examining the stator, which was delta-connected, one coil showed much more evidence of heating than did the others. Had the stator been star-connected, two of the coils would have shown more evidence of heating than the third coil. At all events the evidence proved conclusively that the failure of the motor had been due to single-phase starting or to single-phase stalling, but it could not be concluded as to whether the open-circuit in one phase had occurred inside of the motor or outside of it.

After the motor had been repaired, the operator very wisely installed fuses and a circuit-breaker on the running side of the compensator. E. C. PARHAM.

Schenectady, N. Y.

A Simple Shafting Level

For leveling shafting or two points some distance apart and not convenient to be reached with a straight-edge, it is quite common practice among millwrights, builders and others to take a common garden or other hose, insert



HOSE CONTAINING WATER USED FOR LEVELING

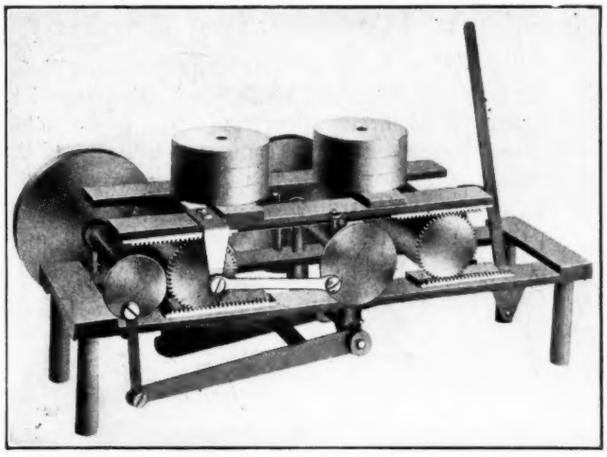
a glass tube in each end, and fill it with water to nearly the tops of the tubes, as shown in the illustration, from which the use of the rig may be easily understood.

I saw a backwoods stone mason leveling the foundation for a small building with a hose, only he didn't use the glass tubes, and the result was entirely satisfactory.

New York City. S. F. WILSON.

Not Perpetual Motion but Perpetual Multiplication

A circular and description (?) of a wonderful "power-multiplying machine" has just been received, "invented" this time in Mexico—where truly, revolutions do multiply. Does modesty prevent or is it unfashionable to invent perpetual-motion machines nowadays? Perhaps stock and shares do not sell well just now under that name. At any rate promoters are forever busy selling "a few shares of capital stock" and not producing com-



THE WONDERFUL MACHINES AS ADVERTISED

mercial machines. Following is a rather free translation from the Spanish, of a display advertisement in Texas papers:

THE ONE THOUSAND PER CENT.

If you invest a dollar and it returns you two, you feel very satisfied; but if it produces you ten, your satisfaction turns into amazement.

The most productive investments are those which furnish the buyers with means by which to multiply their money.

If you need a 10-hp. motor to drive your machinery, you have had, up to the present day, to stand all the expenses corresponding to a 10-hp. motor.

If with a motor of one single horsepower you could move this same plant, 1 hp. would be producing the same as 10, and you would have multiplied your money.

This is what we offer:

A power-multiplying machine which develops ten times the power of any motor, which means:

That if actually you move your shops with a motor of 20 hp., in the future you may move these shops with a motor of 2 hp. and a power-multiplying machine to be charged with the development of the rest of the power, bringing as the result an expense ten times less.

The power multiplying machine has come to meet the solution, looked for since long ago, of this world need.

It is a wonderful Mexican invention, for which a company is being organized to exploit this great discovery, and based on absolute security for the stockholders. This company will be organized with a capital of $300,000 divided in 30,000 shares of $10 each.

To obtain shares in this company it is only necessary to pay $2 on the subscription of each share and the rest in weekly installments of $1 each.

You cannot lose the money you have paid in; even in case you don't pay in your shares in full, we allow the shareholder great privileges.

You have here a unique opportunity to invest your savings and multiply your money.

Come today to our offices at — ——, —.

The —— —— —— Co., Unincorporated.

What will be the efficiency of this machine in separating people from their money? This is simply another crude appeal, by impossible means, in violation of fixed natural laws, to the human weakness of greed and avarice.

San Antonio, Tex. P. LUNDEBY.

Use of 220-Volt Motor on 110-Volt Circuit

In the issue of May 23, under the heading, "Inquiries of General Interest," the question "How would the speed and power of a 220-volt motor be affected if used on a 110-volt circuit?" was answered in a very unsatisfactory manner, I believe. While the answer as given is correct, it is left to the reader to infer that a 220-volt motor will not operate satisfactorily on 110 volts.

The writer has on several occasions tested a 220-volt motor on 110 volts without making any changes in the windings. When the motor is unloaded, the speed will be almost correct as for the 220 volts, but when a load is applied the speed falls rapidly and the current increases. If the field coils are divided into two equal circuits and paralleled, the magnetic field will then have full strength, and as one-half voltage is applied to the armature, its speed will be constant for a shunt motor at one-half its rated speed. The characteristics of the motor will then be the same as when operating on the 220 volts, but as the speed has been halved, the horsepower will also be halved. R. L. HERVEY.

Washington, D. C.

[The page of "Inquiries of General Interest" is for brief generalization only—space will not allow exhaustive discussion. The subject of rewinding and reconnecting direct-current motors and generators to operate on different voltages and at different speeds from those which they were designed for was treated in a series of three articles by A. A. Fredericks, under the title, "Rewinding Direct-Current Motors and Generators," July 20 and 27 and Aug. 3, 1915, issues of *Power*.—Editor.]

Convenient Water Brake

On page 764 of the May 30 issue Thomas Hall describes a "Convenient Water Brake," giving formulas for its application in determining the power of prime movers or motors. Owing to an oversight, no doubt, his formula for horsepower is in error, in the omission of the factor 2. The formula should read,

$$Horsepower = \frac{2\pi WLN}{33{,}000}$$

where

W = Weight in pounds shown by scales supporting the brake arm;

L = Length of brake arm, in feet;

N = Revolutions per minute.

In the use of a brake of this sort the computations will be greatly simplified if the length of the brake arm is made a little over five feet, rather than just three feet, as suggested by Mr. Hall. If L in the formula is made 63.025 in., which equals 5.252 ft., the constant factors in the brake formula reduce to

$$\frac{2\pi L}{33{,}000} = \frac{2 \times \pi \times 5.252}{33{,}000} = \frac{1}{1{,}000}$$

so that we have, for this particular length of brake arm,

$$Horsepower = \frac{WN}{1{,}000}$$

This formula simplifies the computations somewhat, and would lighten one's labor considerably if the brake were used to any extent. Of course this is not restricted

to the water brake, but may be applied to any form of prony brake by the proper adjustment of the length of arm.

One should always be careful in using any type of brake to keep the brake arm at right angles with the line of action of the force exerted by the scales. Usually the scales are so placed that they push vertically upward, hence the brake should be so adjusted that the line adjoining the center of the shaft with the point at which the brake arm bears on the scale is horizontal.

Ithaca, N. Y. C. HAROLD BERRY.

Replacing Boiler Tubes

I have read with interest the discussion on replacing boiler tubes in record time, but for several reasons I do not approve of this way of doing this class of work.

One must admit that there are some cases where the boiler must be put back into service as quickly as possible, but in most plants there is some period of the day when it can be spared more than the 3½ hr., which seems to be the record time for replacing tubes. The assurance of having done a good job will more than repay for the extra time spent in doing the work. Rolling tubes is an important task and should be carefully done. If it is not, there is a possibility of either splitting the tube or not getting it properly expanded, in which case the tube may show leakage on test and the work will have to be done over again. On the other hand, it may be rolled too much with the idea in view of having a tight job the first time, and the tube is made too thin and thereby weakened.

Again, if speed is to be the only consideration, the cause of the tube failure may be overlooked, and there may be other tubes that should have been attended to at the same time, but which in the excitement of making a record may be neglected, making a second job necessary in a short time. We must also consider the comfort of workmen. It is the lot of engineers, boiler men, firemen and other power-plant employees to get a great many emergency jobs where it is necessary to work rapidly in intense heat, but that is no excuse for exposing the men to unnecessary hardships simply to make a record.

Hyattsville, Md. J. C. HAWKINS.

No Reversal of Polarity

I read with interest the useful article on "Building up the Voltage," by Gordon Fox in May 23 issue, but want to call attention to the statement, "If two generators are operating in parallel and the prime mover of one slows down and fails to carry load, . . . the polarity may be reversed, because the series field carrying a current in the opposite direction from normal overpowers the shunt-field influence." The series field never carries a current in the opposite direction from normal under these conditions unless the equalizer connection between the two machines is broken, which would rarely happen.

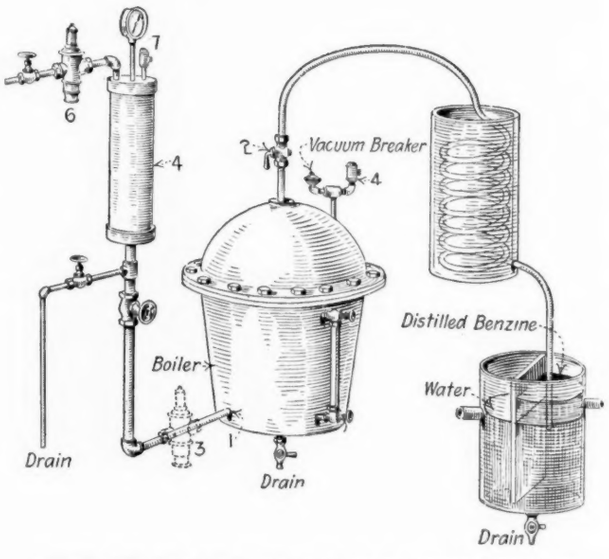
He further states that a generator feeding storage batteries may have its polarity reversed from a similar cause. This cannot happen if the right kind of generator is used for charging storage batteries—that is, a shunt-wound machine—and nowadays, I believe, no one with any experience would attempt to charge storage batteries from a compound-wound generator.

Mr. Fox undoubtedly appreciates the fact that the polarity of the shunt machine remains the same whether it is acting as a generator or as a motor and that one of the functions of the equalizer between two compound machines is to make sure that the condition that he says will result in reversal, in case one machine motors the other, never occurs. H. F. CAMERON.

Lake Charles, La.

Still for Recovering Benzine

The illustration shows the arrangement of a still for cleaning benzine. Steam at 15 lb. for heating the dirty benzine is supplied through the connection 1 to the boiler. The valve 2 is closed until the contents are heated to the temperature of the steam. Then it is opened, and the vapors pass off to the still and are condensed. Separation is effected by the difference in the specific gravity of water and benzine.



COMPLETE STEAM STILL FOR CLEANSING BENZINE

The reducing valve was formerly located as indicated by the dotted outline 3 and often failed to work because, when closing down, dirty benzine was drawn into the working parts. Even when in good condition, after the temperature of the liquid in the boiler was equal to that of steam at 15 lb., the small leakage of the valve would build up the pressure until safety valve 4 would open and discharge benzine vapor, and this amounted to considerable loss.

The trouble was overcome by the piping arrangement shown, which consists of a steam receiver made of pipe and equipped with a gage and safety valve set about 3 lb. higher than the closing point of the reducing valve 6. With this method the reducing valve closes and supplies only the heat lost by radiation. Should the valve leakage exceed this amount, the safety valve 7 on the receiver will open instead of valve 4 on the boiler, which is set to open at a little higher pressure; so that no benzine vapor is lost through the safety valve. BURT N. EVERETT.

Jamestown, N. Y.

Pit Water Caused Trap Trouble

In the issue of May 16, page 705, Leon Lewis suggests placing the trap used for draining the receiver on the floor or above it instead of in a pit below the receiver. I think this is wrong, as a trap will work better if piped up so the water will drain into it. Under certain load and operating conditions, a partial vacuum exists in the receiver for short periods, in which event a drain trap located above the receiver would not be safe. There are on the market traps for successfully handling alternating pressure and vacuum conditions, that will fully meet the changing conditions in receivers, and such traps are, I believe, the logical thing to use, particularly when running condensing.

If carefully and properly installed, a trap in a pit below the receiver will, when given proper attention, be just as reliable as one located elsewhere. Such pits can be waterproofed and provided with steam ejectors for removing water that might find its way in from the floor above.

C. T. Baker.

Jacksonville, Fla.

[The original story appeared on page 564, issue of Apr. 18, and the trap was not given the attention outlined in the closing paragraph of this letter and therefore caused trouble—hence the story—and when attended to it worked satisfactorily. Reference is made in the second letter to the wrong type of trap being used. It is not likely that a vacuum can exist in the receiver long enough for water to accumulate to any extent.—Editor.]

Error in Formula for Sag

I was interested, a short time ago, in an article on engineering formulas. The author dwelt mainly on the probability of mistakes in such formulas and the carrying of those mistakes from year to year through many editions of well-known engineering books. The fact that several books carried the same formulas without the errors being discovered was considered by the author sufficient proof that engineers in general are careless or have too much confidence in one another.

I recently discovered a mistake made in some way or other by an author or printer some twenty or so years ago in the following formula for sag. Instead of "inches" the definition of D should read "feet."

$$S = \frac{PL^2}{8D} + PD$$

where

S = Tension on a sagging rope close to the pulley;
P = Weight of rope per foot;
L = Distance between pulleys in feet;
D = Sag of rope in *feet* (not inches).

Wherever I have found the original article copied, the mistake has been copied also. Kent's Mechanical Engineering Handbook and Same's handbook both repeat the error. The original article appeared in Vol. XII of the A. S. M. E. "Proceedings," under "Rope Driving," by C. W. Hunt, and "inches" is used there. Catalog 054 of the C. W. Hunt Co. also copied it as "inches."

The error may or may not be serious. Since the same formula is applicable to computations for strength of belts, overhead cables, trolley lines, suspension bridges, wires, etc., it is quite possible that someone has inadvertently used the formula in such computations with the result that, with additions of ice or wind loads, they have broken and trains have been tied up. I do not claim that this formula has been the cause of wire breakdowns, but I repeat that it is quite possible that such is the case, for I stumbled across the error myself in connection with making computations for sag in belting. I would also have used it in connection with any suspension problem.

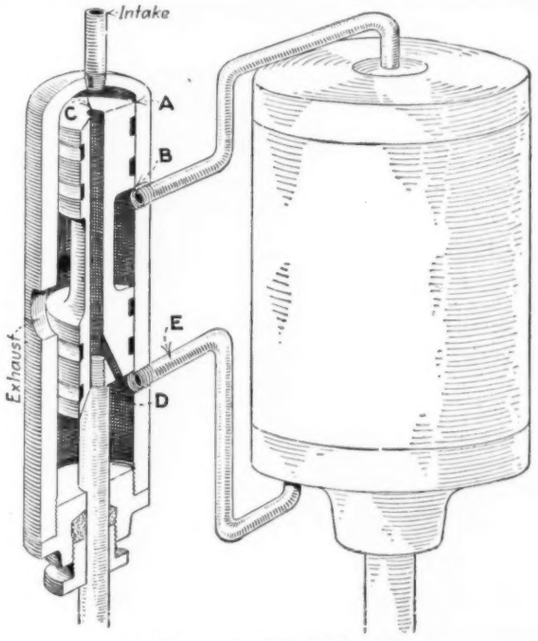
To prove that this error could easily lead to a breakdown, take a sag of ½ in. in a wire 30 ft. between supports, weighing 0.43 lb. per ft. Substituting in the formula as "feet," I get about 1,160 lb. tension. Substituting as "inches," it is only 97 lb. tension. The actual tension, then, would be 12 times the computed.

Since this selfsame formula is applicable to anything uniformly loaded, sagging as per Nature's catenary, I am of the belief that the error is really serious.

New York City. S. F. Wilson.

Four-Way Piston-Type Air Valve

The ordinary four-way valves for controlling the compressed air on barrel-heading machines are expensive and often unsatisfactory, because they leak at 80 lb.—the ordinary pressure. The illustration shows a "home-made"



FOUR-WAY PISTON VALVE

four-way piston valve that has been found more satisfactory.

It is similar to a steam engine piston valve, with the intake at the top and through the valve to the lower end. By pressure on the foot lever the valve is moved downward and admits air on top of the large piston and relieves the pressure from below it to the atmosphere in moving from A to B. By removing the foot the valve goes back from B to A, closes off the air to the top and opens the lower port. Air is admitted through the hollow center of the valve at C, going to the bottom of the valve, leaving at the port D and passing through the pipe E.

This device is inexpensive and has proved very satisfactory.

Thomas Grogan.

Memphis, Tenn.

Prompt Action in Emergencies

Following is an example of good work by the first assistant in temporary charge in the absence of a chief engineer.

Some of the buildings in the group were situated as shown in the illustration. Toward the end of December the amusement hall adjoining the power house was destroyed by fire and the 8-in. low-pressure steam line to the main building was broken and buried under tons of fallen brick, etc. With an outside temperature of 26 deg. below zero, it was imperative to get heat into the main building, where there were about 800 patients.

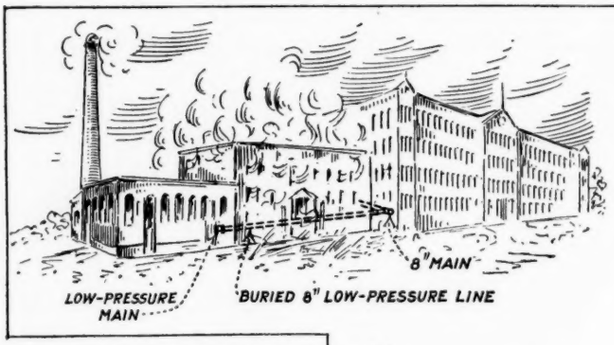


FIG. 1. ORIGINAL RUN OF HEATING MAIN INSIDE

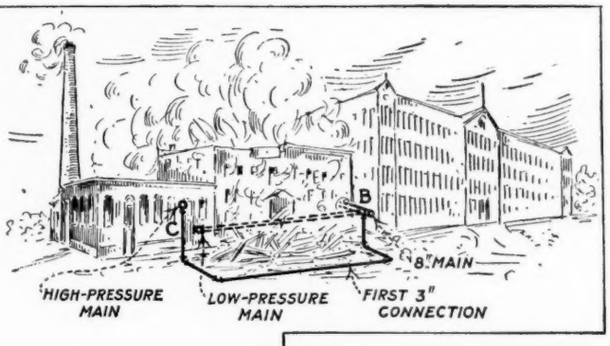


FIG. 2. FIRST EMERGENCY LINE AROUND WRECKAGE

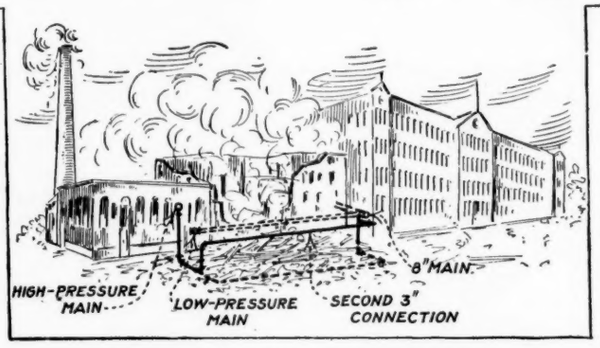


FIG. 3. FINAL LINE OVER THE DEBRIS

Before the fire was extinguished the man in charge connected a 3-in. pipe to the high-pressure steam main *C* and running it along in front of the burning building, connected it to the 8-in. main at *B* and allowed the condensation in the return to escape to the sewer. Some hours afterward another wall fell outward and broke the newly laid 3-in. pipe, burying it deeply under the débris. The engineer disconnected the pipe at *C* and ran another line over the wreckage of the burned building and had steam on the main building again in an hour and a half after the wall had fallen.

Besides the steam pipes several gas and water pipes were broken and electric wires torn down, but inside of 24 hr. a complete temporary service was in operation, and all of the work was done by the engineers' staff employed around the plant and buildings.

It is such unexpected happenings that try the ingenuity and ability of the engineer, and in this case it meant many hours of continuous hard work, the acting chief doing his share of it besides directing the men.

This is no imaginary case, and the editor has all the particulars. The man who had shown what he could do in an emergency refused the offer of the position of chief, as he preferred to work for less money and let someone else shoulder the responsibility, although he had been employed for 38 years at this plant and had observed the many changes in the equipment. He never had been a reader and had always been against book knowledge for engineers; therefore he knew that he had not the requisite knowledge of modern equipment, and in his old age he acknowledged his mistake manfully although too late to rectify it.

JAMES E. NOBLE.

Toronto, Ont., Canada.

Dynamo Bearing Troubles

The bearing on the commutator end of the shaft of a 250-volt 160-ampere direct-current dynamo made trouble by erratic heating. Sometimes it ran for long periods and then suddenly heated and seized before anyone could reach it. In spite of the greatest care the bearing would warm up at the least-expected time, regardless of load or belt tension. The electricians got used to taking out the bearing, cleaning up the shaft and putting in a new supply of oil.

After the third or fourth time it was decided to melt the old babbitt metal out of the bronze half-bearings and replace it with high-grade babbitt, though the old metal was still in good condition. After the new babbitt was put in and the bearing was carefully fitted, the dynamo ran without further trouble. The old metal was carefully examined, but nothing was found wrong with it, nor was any cause ever discovered for the previous freak heating with it.

In the same power house was another dynamo, which ran warm in the similar bearing, but never got hot enough to do any damage. The amount of heating seemed to vary with the load. The bearing never heated beyond a certain point, but often remained at that point for hours at a time. The end of the shaft outside the bearing was hotter than the part inside. The bearing had no apparent defect, and extra oil made little, if any, difference. The electricians decided that it was some hysteresis effect. The last I knew, the dynamo was in operation but ran warm on the end of the shaft without any resulting trouble.

CLARENCE V. HULL.

Charles City, Iowa.

Recipe for Hand Cleanser

A satisfactory cleanser for the hands that costs less than any on the market may be made as follows: To 2 cakes of "Satin Gloss" soap shaved and dissolved in about 3 pints of water, add one 20c. bottle of "Synol" liquid soap, 1 lb. pulverized borax and 2 lb. pulverized pumice stone. Thoroughly mix and thin to suit. Keep in a tightly closed earthenware vessel.

D. CLAIR, SR.

Elizabeth, N. J.

Inquiries of General Interest

Effect of Temperature of Intake of Air Compressor—What loss of efficiency is sustained by compressing warm indoor air in lieu of outside cold air? S. W. P.

The loss in efficiency amounts to about 1 per cent. for every five degrees that the air is taken in higher than the temperature of the outside air.

Steel Used in Boiler Construction—What three classes of openhearth steel are used for the construction of boilers? J. M. L.

The three classes of openhearth steel used in boilers are flange or boiler steel and firebox steel for the plates and extra-soft steel for the rivets and tubes.

Effect of Turning Off Eccentric—How much change will be made in the travel of an engine valve by turning off ¼ in. all around the eccentric? H. O. P.

The valve travel depends on the eccentricity of the eccentric regardless of its diameter, and therefore turning off the same amount all around the eccentric could have no effect on the amount of travel.

Advantages of Corrugated Furnace Sheets and Flues—What are the advantages of corrugated over plain furnace sheets and flues for internally fired boilers? H. A.

When the material of the sheets or flues is corrugated, it offers greater resistance to a collapsing pressure, expands and contracts with less disturbance of other parts of the boiler and presents a greater area of heating surface.

Increasing Lead with Fixed Eccentric—How can the lead of an engine be increased at both ends if the eccentric is keyed to the shaft? C. H. C.

The lead can be increased by reducing the lap of the valve or by removing a portion of the admission edges of the valve by cutting away a portion of the opening edges of the steam admission ports. Either operation will also have the effect of making the cutoff later.

Efficiency of Boiler and Grate—In using coal of 13,600 B.t.u. per pound and obtaining an evaporation equivalent to 9.5 lb. of water per pound of coal from and at 212 deg. F., what would be the efficiency of the boiler and grate? A. L.

Each pound of water evaporated from and at 212 deg. F. would require 970.4 B.t.u., and as the heat realized per pound of coal would be $970.4 \times 9.5 = 9{,}218.8$ B.t.u., the efficiency of the boiler and grate would be $9{,}218.8 \div 13{,}600 = 0.677$, or 67.7 per cent.

Pressure of Liquid on Base of Container—What would be the total pressure and the pressure per square inch on the bottom of a cylindrical vessel 6 in. dia. by 3 ft. high, filled with a liquid that weighs 56 lb. per cu.ft.? S. M.

The area of the base of the vessel would be $6 \times 6 \times 0.7854 = 28.274$ sq.in., and it would contain $28.274 \times 3 \times 12 = 1{,}017.864$ cu.in., or $1{,}017.864 \div 1{,}728 = 0.589$ cu.ft. The total weight or pressure of the liquid on the bottom of the vessel would be $0.589 \times 56 = 32.984$ lb., and the pressure on one square inch of the base would be $32.984 \div 28.274 = 1.166$ lb. per sq.in.

High-Duty Pump Attachment—What is meant by a high-duty attachment on a steam pump? J. B.

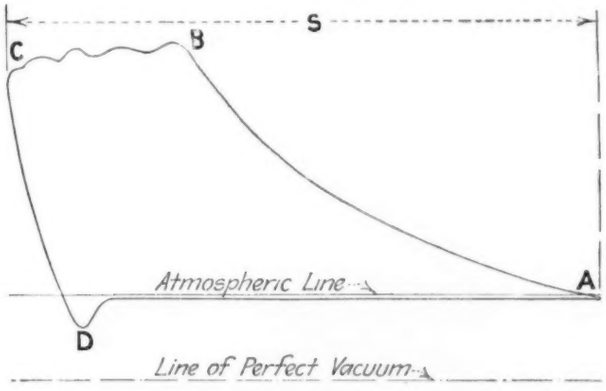
In an ordinary direct-acting steam pump, steam is admitted full stroke without obtaining the economic benefits of expansion after cutoff. It is the purpose of the high-duty attachment to secure the advantages of expansion by storing surplus energy developed during admission and early expansion of the steam and, by suitable mechanism, redistribute the stored energy to those portions of the stroke in which the pressure of expansion has fallen below the pressure required for overcoming the resistance.

Relative Heating Value of Upper and Lower Tubes—In a return-tubular boiler are the tubes of the upper rows or of the lower rows of greater heating value? W. M. S.

For the same amount and temperature of furnace gases presented to the tube surfaces, the tubes of the lower rows would be more efficient than those of the upper rows, as transfer of heat is more rapid to the colder and denser water surrounding the tubes in the lower part of the boiler. But in most boiler settings the heated furnace gases are returned by easier courses through the upper rows of tubes and, because of the greater amount of heat thus presented, their heating surfaces are of greater value than equal heating surface of the lower tubes.

Indicator Diagram from Air Compressor—How are the events in operation of an air compressor shown by an indicator diagram taken from the air cylinder? B. R.

A diagram from the air cylinder of a compressor is similar in general form of outline to one taken from a cutoff engine, but the portions of the latter that represent the events of admission, expansion, exhaust and compression are of reverse significance. In the annexed illustration of a typical compressor diagram, S represents the volume displaced by the piston in one stroke. The lines constituting the actual diagram are AB, compression line; BC, delivery line; CD, expansion line; and DA, admission line. Starting with the piston at A and the cylinder full of air, the pressure of the confined air rises as its volume becomes reduced, by movement of the piston, until a pressure B is obtained somewhat higher than necessary for opening the release valve. In continuing its motion from B to the end of the stroke, the piston forces the compressed air into the receiver. The wavy line



TYPICAL COMPRESSOR DIAGRAM

BC in the diagram is due to fluttering of the discharge valve and inertia of moving parts of the indicator. Upon completion of the stroke the pressure of air in the receiver closes the discharge valve, leaving the clearance space filled with compressed air. Then, as the piston returns toward A the compressed air in the clearance space expands until a pressure below that of the atmosphere is reached, as at D, when the inlet valve opens and free air flows into the cylinder until the piston arrives at A, completing the intake stroke.

Cushioning of Duplex Steam Pump—How is cushioning by compression of exhaust steam secured in a duplex steam pump? W. M.

Near each end of the steam cylinder there is a passage for admitting live steam and a separate passage nearer the middle of the cylinder for discharging the exhaust. The normal length of stroke is sufficient for the piston to cover the exhaust passage before completing its stroke. When escape of the exhaust is thus cut off, any steam that remains on the exhaust side of the piston is compressed in the end of the cylinder and live-steam passage and acts like a cushion for the piston to work against for the remainder of the stroke.

The steam cylinders of some pumps have valves, called cushioning valves, for regulating the amount of cushioning. This is accomplished by permitting more or less of the exhaust steam that is compressed into the steam passage to escape through the partition between the steam and exhaust passages and thence discharge through the open exhaust port.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Report of Station Operating Committee--II

SYNOPSIS—The first part of this report, printed in the June 13 issue, covered Boiler Operation. This second part deals with Water Treatment and in subsequent issues will be covered the other two parts on Extraction or Bleeder Turbines and Oil as Fuel.

Water Treatment

A water softener at the Fifty-ninth St. station of the New York Steam Co., has given the following results:

From Sept. 22 to Oct. 26 last, the average hardness as shown by the titrations of the treated water was $\frac{6}{10}$ of a grain. The average causticity was 1.09 grains and the average alkalinity was 2.58 grains, all per gallon of water treated.

Usually where a titration for hardness with soap solution is read directly from the burette in grains per gallon, 1 is deducted from the reading, as it requires the equivalent of one grain per gallon to form a permanent lather on distilled water. In the readings of average hardness given, ½ grain per gallon was deducted instead of 1, as it is practically impossible to get a soap solution nearer the accuracy of a gravimetric analysis than ½ grain per gallon.

During December the hardness increased with no change in the strength of the solutions fed, and the results for December were: Hardness, 0.7; causticity, 0.95; alkalinity, 2.1. The hardness is shown after taking the direct readings of the burette and deducting 0.5 as the quantity of soap solution required to form a permanent lather.

In December boiler No. 9 was opened after a continuous run of three months at 200 per cent. of rating, and some scale was found. It was relatively soft, as it did not require a turbine to remove it, but it should not exist. An examination was made of the chemicals used in the treatment, and it developed that the lime had been shipped in jute sacks through which the air could pass and that it had deteriorated. It was also found to contain a quantity of impurity insoluble in dilute hydrochloric acid. This accounted for the increase in hardness. Soda ash in the meantime had advanced materially in cost, and a sufficient amount of chemical was not being fed.

On Feb. 2 boiler No. 11 was opened after a continuous run of three months at 200 per cent. of rating. The caps on the four bottom rows of the tubes only were removed. No scale was found adhering to the tubes. Some loose pieces were in the tubes, probably carried there from some other part of the boiler by the circulation. Scale had formed on the front header. It would accumulate to nearly $\frac{1}{16}$ in. thick and then break up and drop into the bottom of the header.

Scale should not form in a water of the quality used as shown by the titrations given, and a search was made for the cause. It was found that the filter was being washed with untreated water without being drained. Consequently there was fed into the boilers raw water containing $5\frac{3}{10}$ lb. of scale-making matter per day, equivalent to $487\frac{6}{10}$ lb. for the three months' run. In spite of this, No. 11 boiler was so clean that the tube caps were replaced and it was put into commission the same day for another run of three months.

The total labor charge for operating this large softening plant (for 20,000 hp.) is but $35 per month. The results obtained develop a fact that is of great interest—that scale will form where boilers are operated at such high rating, if the water contains a hardness such as is usually obtained in the average water-softening plant. That is, boilers will not be free from scale if fed with a water of 4 grains hardness, therefore a greater refinement must be obtained to meet this condition.

The demand for 200 per cent. of rating is growing, as more and more plants are being built to operate at that rating, and greater care will have to be taken to put into such boilers water containing the least possible hardness. Again, special attention will have to be given the quality of water being treated, as the highly soluble soda salts remaining in the water after treatment, owing to the reaction between lime and magnesia sulphate and soda ash, will cause trouble if they exist in quantity beyond a few grains per gallon.

Some very interesting experiments have been made in the last few years by J. H. Andrew and reported in the "Proceedings" of the Farraday Society, to determine the effect of caustic soda on iron and steel plates. Briefly summarized, Mr. Andrew's research has definitely proved that saturated solutions of caustic soda cold will embrittle or crystallize either iron or steel plates in from 21 to 45 days' submersion.

THE EFFECT OF CAUSTIC SODA ON IRON AND STEEL

The theory upon which the effect of these salts on iron and steel is based is that, "In the presence of caustic soda and iron, water splits up, the oxygen forming ferric oxide or acid, which combines with the caustic, while hydrogen is occluded by the metal." The hydrogen enters the amorphous phase of the metal, and its pressure changes the structure of the metal from fibrous to crystalline. In the crystalline stage it is very brittle. Upon heating, a crystallized plate releases hydrogen and it assumes again its fibrous structure.

It is well known that soda ash is not a stable salt at temperatures found in boilers. It releases its carbonic acid, becoming in the presence of water, sodium hydrate or caustic soda.

If saturated solutions of caustic soda will crystallize iron and steel plate in a few days' time, will not dilute solutions cause the same effect if given sufficient time—say months or years? It is fair to presume that this is true, and the presumption is borne out by experience with boilers whose feed water contained bicarbonate of soda.

In the Central West many artesian-well waters contain bicarbonate of soda which, under the temperatures existing in a boiler, will change its form to caustic soda or sodium hydrate. In some 22 instances serious boiler troubles have occurred, such as cracked plates, tears, ruptures and explosions, where this class of water was used as a boiler water. Each of the 22 cases is identical in that the troubles all occurred in seams below the water line. There was no apparent reason for the trouble, other than the fact that caustic soda was present in the feed water, nor could any other cause be located. It was evident that it was not due to the industry operating the plant, as the trouble occurred in central-station heating and electric plants, in flour mills, brickyards and other manufacturing plants.

Where trouble occurred it was invariably in the seams—cracks would occur in the plates of shells and drums. They were always below the water line. They never extended into the plates beyond the lap of the seam. They were small, seldom more than an inch long. When first appearing, the surface of the plate was the first to show. As time went on, the cracks deepened until the thickness of the plate was affected. Examinations showed that the metal had crystallized wherever the cracks existed, while other parts were perfect.

All types of boilers met the same experience, therefore it could not be laid to the type. In 22 cases it was not reasonable to suppose that various and prominent manufacturers had all used defective material or had permitted defective work to come out of their shops.

The indication that caustic soda hydrogen occlusion was the cause is sufficiently strong to make us all careful—careful in the use of caustic soda or soda ash as a boiler compound and careful in the operation of water softeners to keep the excess soda ash, as shown by the causticity titrations, low.

In one plant where a water of this character is used, no trouble of this kind has occurred, but this may be because only a small quantity of the substance is present.

There must be some point where danger begins, and while this point is not known as yet, it will no doubt be determined later on, and whoever makes known the determination will deserve credit from every user of a steam boiler.

NAVY BOILER COMPOUND

The technical press has given some prominence to a paper presented at the December meeting of the American Society of Mechanical Engineers in New York City, by Mr. Babcock, consulting electrical engineer of the Southern Pacific Co.

This paper describes the trouble experienced with pitting and corrosion at the Fruitvale power house of the Southern Pacific Co., using a softened water, and assumes a cause and describes the cure as applied by themselves. Reading Mr. Babcock's paper, you can draw but one conclusion—that Navy boiler compound is a cure for all cases of pitting and corrosion, and this seems to be a narrow conclusion and one that is open to question.

In the first place his assumption is that no other cure could be found, which is questionable, and there is also a

question whether their solution of the problem will not lead to more serious consequences than pitting and corrosion of boiler tubes.

At the Fruitvale power house a softened water was used. After softening the water, it contained no substance that could possibly contribute to pitting and corrosion of tubes. Waters much worse in every way, especially as far as corrosive elements are concerned, are in use after treatment in boiler plants scattered all over the United States, without any such trouble being experienced as at Fruitvale. Therefore the quality of the water was not the cause.

A Western railroad equipped with water softeners over its entire line, and where the softeners had been in service several years, was suddenly confronted with serious pitting of tubes in locomotive boilers. The quality of the water used had not varied; there was no variation in the method of treating it; there was no variation in the method of evaporating this treated water into steam. Intelligent investigation located the trouble in the impurity in the metal of which the tubes were made—located it so definitely that the tube manufacturers refunded to the road $26,000 to reimburse it for the defective tubes.

The use of Navy compound brings about a condition in the operation of a boiler that no uptodate manufacturers of water-tube boilers would knowingly submit to. The theory of Navy boiler compound is to increase the density of the water to a point where its osmotic pressure will overbalance the tension pressure in the steel. It means using a water of 3 per cent. normal alkalinity, equivalent to feeding and maintaining 92 grains per gal. excess soda ash.

If Mr. Andrew's determinations on crystallization of iron and steel plates by caustic soda are of any value, the result at Fruitvale will be seam lap cracks, tears, ruptures or explosions. A chance has been taken which few boiler operators would care to assume.

Without considering the trisodium phosphate used in Navy compound to prevent foaming and without considering the starch used to keep the impurity precipitated from the water in circulation so it will not settle on sheets or tubes, the density of the water in the boiler after 36 complete evaporations would be 1.017 or 998.667 grains per gallon. Sea water has densities varying from 1.026 to 1.03, and the Navy boiler compound treated water is more than half the density of sea water.

Many tubes have collapsed in water-tube boilers using waters with a density of 1.0032, and a pertinent question is what is the tube loss at the Fruitvale plant from density? Mr. Babcock refers to loss of tubes from other causes than pitting and corrosion, and it is no doubt due to the density of the water they are evaporating.

The whole tendency of the times is to obtain high evaporative capacities from boilers, and this can only be accomplished by the use of feed water of low density and containing little if any scale-forming material.

H. G. N. Nutting, of the Mineral Point Public Service Co., has kindly furnished the Station Operating Committee with a statement of the results obtained from their water softener at Mineral Point, which follows:

ANALYSIS OF RAW WATER

Incrusting Solids

Substance:	Grains per U. S. Gal.
Cal. carbonate	10.00
Mag. carbonate	2.39
Mag. sulphate	8.28
Mag. chloride	0.24
Iron and alumina	0.35
Silica	0.35
Suspended matter	0.58
	22.19

Nonincrusting Solids

Substance:	Grains per U. S. Gal.
Sodium chloride	3.21
Sodium nitrate	Trace
	3.21
Hardness	20.44
Alkalinity	12.85

The average condition of the treated water titrates, as follows:

	Grains per Gal.
Hardness (soap test)	7.1 pt. per 100,000 equal to 4.15
Causticity (alkalinity to phenol)	4.0 pt. per 100,000 equal to 2.34
Alkalinity (to methyl orange)	7.1 pt. per 100,000 equal to 4.15

A Firetube Steam Superheater, in use for three months on the tug "Wyoming," belonging to the Lehigh Valley R.R., is reported to have effected a fuel saving of slightly over 15 per cent. Other vessels of the fleet will soon be similarly equipped.

Recommends Against Municipal Electric Plant

A committee consisting of F. W. Ballard, Foster Olroyd and Alfred Raymond, which was appointed by the City of New Orleans to investigate the feasibility of having its own municipal electric-light plant, has reported against the project.

In arriving at this decision local conditions were taken into account as well as the recent reduction in rates by the local company, and it was concluded that it would not be practical for the city to construct and operate a municipal plant and share with the existing company the present or potential business of the community at rates more advantageous than those recommended by the committee. These recommended rates are somewhat lower than the present reduced rates and provide for a flat rate of 6c. per kw.-hr. for all commercial and residential light customers up to and including the first 200 kw.-hr. used in each month and 4c. per kw.-hr. for all energy consumed in excess thereof, with a service charge of 25c. per meter and a minimum consumption of 50c. per month.

New York State Convention N. A. S. E.

The twenty-first annual convention of the New York State Association of the National Association of Stationary Engineers was held at Yonkers, June 8, 9 and 10.

The meetings of the delegates were held in the officers' quarters of the armory, and the large drillroom adjoining was tastefully decorated and arranged to accommodate the mechanical display of the supplymen. The exhibit was formally opened on Thursday morning; there were upward of sixty booths, and there was a generous attendance during the three days.

The first session of the delegates was held at 9 o'clock on Friday morning, with Lewis Bernard, the chairman of the local committee, in the chair. An address of welcome was made by Mayor James T. Lennon of Yonkers, which was responded to by William H. Aydelotte, state president. Dr. Nathan Warren, president of the Chamber of Commerce, also welcomed the delegates and guests. Walter H. Damon, national president of the N. A. S. E., briefly outlined the benefits and advantages of membership in the organization. The

N. Y. STATE CONVENTION N. A. S. E. AT YONKERS

convention then went into executive session, and after the several necessary committees were appointed the meeting adjourned until 10 o'clock Saturday morning.

At 1 o'clock on Friday afternoon the convention made an inspection of the extensive plant and works of the Otis Elevator Co. The guests were cordially received, and a luncheon was served at which Edward A. Fitch and M. Christopher, of the Otis company, addressed the delegates, and Jack Armour, of "Power," entertained. Other features of entertainment included a visit to the City Hall, where the late improvements in the receipt and transmission of fire alarms were shown, and the latest ideas in taking the measurements of criminals by the Bertillon system were explained. There was also an interesting demonstration of automobile fire pumps by the Yonkers Fire Department.

At the final meeting of the delegates the following state officers were elected: William H. Aydelotte, Niagara Falls, past president; William H. Downey, New York City, president; George Van Vechten, Rochester, vice-president; William Roberts, Yonkers, and William Downes, New York City were

reëlected secretary and treasurer respectively; Stephen H. Wright, Brooklyn, conductor; John Elder, New York City, doorkeeper; George A. Eli, Rochester, chaplain; John J. McGowan, Brooklyn, state deputy. The officers were installed by Past National President William J. Reynolds.

Retiring President Aydelotte was presented a mahogany chime clock and his wife a handsome serving tray of the same material, Past President William J. Reynolds making the speech on behalf of the delegates. Addresses were made by National President Walter H. Damon, Past Presidents James R. Coe and W. J. Reynolds and J. D. Taylor, of the life and accident department. It was voted that in the future the sum of fifty dollars would be given to the convention city to help in defraying the expenses. Before adjournment memorial services were conducted by the Rev. Dr. James S. Holland, assisted by Miss Cynthia Roberts, daughter of the secretary.

Rochester was chosen as the next place of meeting in June, 1917.

California N.A.S.E. Convention

The thirteenth annual convention of the California State Association, N. A. S. E., was called to order at 2:30 p.m., Friday, May 26, at the Arlington Hotel, by Vice-President Harry Wood in the absence of President T. W. Ireland. Colin H. McIsaac, secretary of the Santa Barbara Chamber of Commerce, welcomed the delegates and their ladies to the city. Harry Wood responded in a fitting manner, after which the first business session was held with 25 delegates in attendance. The annual address of the president was read, followed by the report of the secretary, treasurer and the chairman of the educational committee, all of which were referred to the ways and means committee to be reported on at the Saturday morning session.

A stereopticon lecture on Japan, by George A. Reichard, was enjoyed by a large audience in the evening at the auditorium of the State Normal School. The pictures were of more than general interest as they were taken by Mr. Reichard during his eight months' sojourn in Japan while installing air-compressor plants in the oil fields.

At the Saturday morning session the ways and means committee recommended the retention of the educational committee of 1915 and that the suggestions of the president and chairman of the committee be followed in selecting some one subject for discussion for the year.

During the session a paper was read from John R. Brownell, superintendent of the Department of Safety of the State of California, on the "Stationary Engine Safety Orders and Their Purpose," which was highly instructive.

C. C. Elsasser, of No. 3, of San Francisco, was selected as the state deputy, subject to the approval of the national president after the national convention in Minneapolis.

Harry Wood presented to the several associations in the state association sets of mechanical charts which will be of value to the members.

On invitation of F. W. Coombs, of San Jose, Calif., it was voted to hold the convention in that city in 1917.

The following were elected and installed as officers for the ensuing year: President, Harry Wood, No. 5, Santa Barbara; vice-president, F. W. Coombs, No. 6, San Jose; treasurer, Charles Knights, No. 3, San Francisco; secretary, W. T. W. Curl, No. 2, Los Angeles; conductor, E. G. Steel, No. 5, Santa Barbara; doorkeeper, F. J. O'Donnell, No. 2, Los Angeles; trustee (three years), W. H. Traster, No. 2, Los Angeles.

The banquet in the evening was attended by the delegates and their ladies as well as the members of No. 5 and some of Santa Barbara's citizens. A Spanish barbecue was enjoyed at Veronica Springs, Sunday.

Purchasing Coal by Test*

The purchase of coal by a public-utility company should be more than an ordinary purchase—it should be the one item to have careful study and thought, because it is a big factor, if not the largest, in the cost of production. The day for thinking "coal is coal" has passed. The buyer should not be influenced by what a certain coal has done in some plant other than his own. Each has a problem that is peculiarly his own, and it must be treated in that way. It is well to know how different coals will act in different plants, for the reason that the characteristics of each particular coal will thus be made known.

The question then arises, how should the purchase be made? After it is made, should it not be a daily purchase instead of once a year? Should not each day's, each week's, each month's coal be given the same careful attention that the first purchase was given? How many times has it happened that careful study and an immense amount of time and money have been devoted to carefully picking out the coal for a plant, only to have trouble later?

So far as the cost of coal in a plant is concerned, the real figure that tells the story as to the best and cheapest is, which coal will evaporate a unit quantity of water at 212 deg. F. into steam at the least cost. To determine this, the following applied formula may be used:

$$\frac{\text{Price of coal del. (\$2)}}{\text{Pounds in a ton (2,000)}} \times \frac{\text{pounds of steam (1,000)}}{\text{evaporation from and at 212 deg. (7.5)}} = 13.33\text{c.}$$

This method of getting the cost is based on evaporation tests. The coals available for a certain plant should be grouped together in like kinds, according to locality of mines, the seams being operated and the characteristics of the coal. If, for instance, it is known in a plant that a screening from a certain seam serves the plant economically, then coals coming from that seam should be tested and the one producing the best cost figure carefully considered. If it is found, after testing one car, that it is satisfactory and is the cheapest of, for example, five different samples submitted, then an additional supply of possibly three cars should be ordered, and if these are satisfactory, then ten cars, or enough to cover a period into which all plant and coal variations and conditions may enter.

Here is where the laboratory comes into play and should be of real value to coal buyers. Keep in mind that a coal in one car was tested in a practical way and found satisfactory. The future deliveries should be identified with the test coal. The next three cars after the first should be sampled in the same manner, then the ten cars, and so on until the operations cover a period of time sufficient to get a real average which will be the basis of comparison for future deliveries. The length of time for this average depends upon the tonnage used. A plant using a car a day should be able to get an average easily in one month's time, by having analyzed the sample from the first car, a composite of the samples from the next three cars, and then a composite of all samples, say, from each five cars thereafter for the first month. The analyses on all this coal should be reduced to the net heat units obtained for one cent.

Assume that the analysis is: Moisture, 10 per cent.; dry ash, 10 per cent.; dry B.t.u. (heat units in a pound of dry coal), 13,000; price, $2.50 per ton of 2,000 lb. The net B.t.u. for one cent would then be obtained as follows: Deduct 10 per cent. of the dry B.t.u. as correction for moisture, which would give 11,700 B.t.u. per pound of coal, or 23,400,000 B.t.u. per ton of 2,000 lb. Assuming an arbitrary figure of 50c. per ton for ash removal, the cost of removing 10 per cent. of ash in the coal under discussion would be 5c. This amounts to the same thing as taking one-half of the percentage of dry ash and expressing the result in cents. Adding this to the cost of the coal would give a total of $2.55 per ton. Then dividing the B.t.u. in a ton of the coal by 255 would give 91,764.8 net B.t.u. purchased for one cent.

This analysis and the net B.t.u. obtained for one cent can then be used for future comparisons. For example, should a coal be delivered showing an analysis of moisture 10.85, dry ash 11 per cent., dry B.t.u., 12,850, then the value of this coal as compared with the standard would be determined as follows: Correct the B.t.u. content for moisture as before and determine the B.t.u. in a ton, which in this case would amount to 22,911,549. Divide this figure by the standard, 91,764.8, and the quotient will be $2.4967. Then deducting $11 \div 2 = 5.5$c. for the removal of the ash gives a net price of $2.4417 per ton. It will be seen that this coal is worth $2.44 instead of $2.50 per ton. An increased price will likewise show when a better grade is delivered.

Samples should be gathered from each car and about three or four analyses made each month by compositing the samples accordingly. There is no question about the composite samples truly representing the whole, providing they are properly taken.

There are many coal companies that oppose bitterly any plan where analysis work is to be done. Some of them have just cause, as this system has been most grossly abused by those who did not know how to use it and carry it on in an equitable manner and in a way by which the truth could be obtained.

*Abstract of paper read before the Missouri Public Utilities Association, by W. D. Stuckenberg, president of the Commercial Testing and Engineering Co., Chicago.

Some coal men say that the fact that the coal comes from a certain mine is sufficient guarantee that the proper quality has been delivered. This cannot be depended upon, as the following instances will show: A plant was receiving mine-run coal. The analyses from time to time showed the coal to have increased in ash 5 or 6 per cent. above the standard. The railroad expense bills showed the coal to have come from the same mine, but when it was examined it was found that large pieces of slate and fire-clay were present. Some pieces would measure 12 or 14 in. in breadth and 2 or 3 in. in thickness; others were long and slabby. Impurities of such size were positive proof that the coal was not being inspected as it should be. The representative of the coal company said their mine manager was in New York and had been for several weeks past. The miners knew it and were taking advantage of his absence to increase their tonnage and revenue. Another time the percentage of ash in some screenings, which ordinarily would average 19 per cent., jumped to 25 per cent. An investigation showed that the miners were sending out what was termed the "gob" in the coal instead of loading it separately into a refuse car.

It is good practice to gather a sample from a wagon before it has been unloaded onto a pile or into a bunker for the reason that the coal, if it is a screening or a mixture that is made up of different sizes, will have separated but little. If the wagon is a tail-gate dump, the sample should be gathered by starting at the bottom of the exposed face of coal and taking a little from bottom to top of the load. This should be done in three or four different places. The main idea is to get a fair average. Samples should be taken after the car has been partly unloaded. If it is of the flat-bottom type and is unloaded by hand, it is usually the practice for the men doing the unloading to go straight to the bottom. Then the same procedure of starting at the bottom and proceeding to the top of the exposed surface should be carried over four or five different places on that surface. This should be done in the ends and middle as the car is unloaded, so that a little coal is taken from practically all parts of the car. At least 150 lb. should be gathered in this way. The same general principle of collecting samples from the exposed surfaces should be followed in all cases.

It is not unusual nowadays to find a "minimum ash-fusing temperature" specified in coal contracts. This temperature is at present one of the best indications of the clinkering properties of the coal under consideration.

Previously some relations were looked for between the chemical composition of the ash and the tendency to clinker, the belief being prevalent that a high-sulphur coal with a consequent high iron content, would give trouble in a firebox. Others went farther, and in addition to the iron, determined the amount of lime and silica present in the ash believing that the presence of such acid and basic substances in one mixture would cause the formation at high temperature of compounds of iron and lime with silica and thus form clinkers.

The latest work on this subject, where both chemical analyses and fusion determinations were made, show that there is no positive relation between the two. Some ashes with a high iron content have a higher fusing temperature than others with a low iron value; some with a low silica content fuse at a higher temperature than others containing a greater amount of silica. The company of which the author is president, in an investigation recently concluded, had attacked this subject from another direction. Three samples of coal, one each from three different mines, were used. The ash and sulphur were determined in the raw coal and the fusion temperature of the ash was observed. The coal was then washed and similar determinations made on the washed coal. As was to be expected, the ash and sulphur content of the washed coal was naturally less than that of the corresponding raw coal. The surprising feature was that the fusion temperature of the ash was practically unchanged. If anything, the ash of the washed coal softened at a slightly lower temperature than the ash of the raw coal. This seems to show that the fusion temperature depends rather upon the fusibility of the intrinsic part of the ash (noncombustible material in the coal matter itself) than upon that of the extraneous ash (noncombustible material from floor or roof of mine and from bands or partings in the seam). Also the amount of ash in the coal seems to have no effect on the fusion temperature. The foregoing statements apply only in those cases where the coal is burned unmixed with such impurities as sweepings and like refuse. In such instances where all refuse is incinerated in the furnace, clinkering may occur even with a coal whose ash shows a high fusion temperature. If clinkering occurs under such conditions, the fault should be charged to the coal only with caution. The conditions in the firebox are changed or the draft is choked owing to the fine ash from some kinds of refuse or wood mixing with the unburned or partly burned coal. As a result, the combustible impurities in the coal, such as pyrite, are not oxidized properly, and instead of the pyrite burning to ferric oxide, a refractory substance, it is reduced to ferrous sulphide, a readily fusible compound which will bind together the material on the grate to form clinker. Naturally, in power plants where large amounts of slack or fine coal are burned, much the same conditions exist and clinker may be found. By insuring a free access of air to the fire, much of this trouble may be avoided. Conditions of firing should be looked into carefully before a coal is condemned for clinkering.

If a coal clinkers, a determination of the fusion temperature of the ash should be made. If this temperature is low, the source of the trouble is probably located. If the fusion temperature is high, the trouble should be looked for elsewhere. In all events it is important to determine the fusion temperature of the coal ash.

ENGINEERING AFFAIRS

American Water-Works Association—The thirty-sixth annual convention of the American Water-Works Association was held at the Hotel Astor, New York City, June 5-9. Leonard Metcalf, consulting engineer, of Boston, Mass., was elected president for the ensuing year.

The American Society of Safety Engineers will hold its next regular monthly meeting on Wednesday, June 28, 1916, at 8 p.m., in the Engineering Societies Building, 25 West Thirty-ninth street, New York City. The session will be devoted to an illustrated lecture on the construction, maintenance and operation of elevators, by Gordon Ebsom.

Ohio Steam Heating Association is the name of a new organization being formed by leading men in Ohio, who are interested in the steam-heating business. The object of the organization is to conduct a publicity campaign to bring to the attention of the public the advantages of steam and hot-water heating, and it will have nothing to do with prices or labor matters. The officers selected tentatively are Frank H. Field, Columbus, president; W. H. Conklin, Columbus, first vice-president; J. W. Bryce, Springfield, second vice-president, and A. W. Miller, Peerless Heating Co., Columbus, secretary, treasurer and business manager.

The New York Section of the Illuminating Engineering Society held its final meeting of the season in the assembly room of the United Electric Light and Power Co., 187th St. and Broadway, New York City, Thursday, June 8, at 6:15 p.m. The meeting was preceded by a dinner, after which W. T. Dempsey, of the New York Edison Co., read a paper on "Electric Street Lighting in New York." Lantern slides were used to demonstrate how the lighting equipments have been standardized to meet the various conditions throughout the city. The methods of installation, construction and maintenance were shown by moving pictures. After the meeting an 18-mi. auto inspection tour was made through Manhattan and the Bronx to see exhibits characteristic of how the various street-lighting problems in New York have been solved.

MISCELLANEOUS NEWS

The Montana Power Co. has recently arranged with the S. Morgan Smith Co., of York, Penn., for four 15,000-hp. and two 16,000-hp. vertical hydraulic turbines. The four 15,000-hp. units are to be installed in connection with the company's Holtzer development on the Missouri River. The 16,000-hp. units are for its Great Falls plant; this will make the capacity of the latter plant approximately 100,000 hp.

OBITUARY

BURNHAM HANSON

Burnham Hanson, for many years chief engineer and master mechanic of the Cocheco mills, at Dover, N. H., came to the end of a life of usefulness and well doing in that city, on June 6. He was one of the early typical New England millwrights and mechanics and had kept abreast with the development of steam power as applied to factory purposes from its earliest stages. He had recently celebrated his 91st birthday and carried away a wealth of reminiscences of New England steam practice.

SILVANUS P. THOMPSON

Silvanus P. Thompson, the well-known English electrical engineer and physicist, died in London on June 13 in his sixty-sixth year. Born at York, June 19, 1851, he was educated at Bootham School, the Founders' Institute and the Royal School of Mines. He served as professor of experimental physics at University College, Bristol, from 1876 to 1885 and later accepted a call to the University of London. Mr. Thompson visited the United States some years ago, at which time he delivered a number of scientific lectures. However, he was perhaps best known here by his writings on dynamo-electric machinery and electro-magetism, upon which subjects he was a recognized authority.

PERSONALS

Ralph James has been appointed superintendent at Junction City, Ore., for the Oregon Power Co.

W. A. Leuenberger, superintendent of the Tacoma Gas Co., Tacoma, Wash., was elected a director of the Tacoma Rotary Club at the annual meeting held June 1.

F. M. Hildreth, formerly superintendent at Junction City, Ore., for the Oregon Power Co., has been appointed superintendent at Corvallis to succeed R. U. Steelquist.

R. U. Steelquist, formerly manager of the Oregon Power Co., at Corvallis, Ore., has been appointed superintendent of the Dallas division, succeeding A. L. Martin.

Stuart H. Parson assumed the management of the Pittsburgh branch of the Foster Engineering Co. on June 1, succeeding William J. Snyder, who is no longer connected with the company.

George J. Young, professor of mining engineering at the University of Minnesota, has been appointed to the professorship of metallurgy at the Colorado School of Mines, to take effect Sept. 1.

A. L. Martin, formerly manager of the Dallas, Oregon, division of the Oregon Power Co., has been appointed superintendent of the Coos Bay (Marshfield) division of the company, succeeding R. M. Jennings, who has resigned.

W. A. Phillis, formerly with the metallurgical and advertising departments of the National Tube Co., Pittsburgh, Penn., has been appointed as advertising manager in charge of the publicity and advertising of "Beaver" pipe cutters and dye stocks for the Borden Co., Warren, Ohio.

F. R. Blair, formerly secretary, treasurer and sales manager of the S. K. F. Ball Bearing Co., Hartford, Conn., has resigned and has become president of F. R. Blair & Co., Inc., with offices at 50 Church St., New York City. It is understood that Mr. Blair is engaged in developing motor efficiency devices.

D. A. Lucas, of Havelock, Neb., has been elected president of the Master Boilermakers' Association of the United States. The other officers chosen at the meeting in Cleveland May 26 were John B. Tate, Altoona, Penn., first vice-president; Thomas Lewis, Sayre, Penn., second vice-president; Harry D. Vought, New York, secretary and Frank Gray, Bloomington, Ill., treasurer.

James A. Green has been appointed vice-president and general manager of the Northern Idaho & Montana Power Co., and in this capacity will coöperate with Elmer Dover, vice-president of H. M. Byllesby & Co., in charge of Pacific Coast properties and president of the Northern Idaho & Montana Power and Oregon Power companies, in the operation of the Byllesby properties in Montana, Idaho, Oregon and Washington.

J. L. White, formerly manager of the Albany, Oregon, division of the Oregon Power Co., has been appointed superintendent of the Willamette Valley division of the Oregon Power Co., comprising the Cities of Eugene, Springfield, Albany, Corvallis, Dallas and other communities, and in this capacity will assist Attilla Norman, vice-president and general manager of the Oregon Power Co., whose duties have been extended to include the Coos Bay (Marshfield) division of the company.

NEW PUBLICATIONS

A HANDBOOK ON INCANDESCENT LAMP ILLUMINATION. Issued by the Edison Lamp Works of the General Electric Co., Harrison, N. J. Flexible leather; 2¾x5½ in.; 212 pages; illustrated. Price, 75c.

This book is a new edition of the 1913 issue. The information has been brought up to date and much new material added. The work is divided into four sections: Sec. 1 treats on incandescent lamps, lamp construction, rating and performance, the maintenance of lamp installations and cost of light; Sec. 2, definitions, units of illumination and photometry, illumination calculations, reflectors and accessories; Sec. 3, lighting practice, giving a description of methods of illumination, relation of light to architecture, along with data for the proper lighting of private, public and industrial buildings; Sec. 4 deals with electric circuits, electric wiring, National Electric Code, rate schedules, meters, with a collection of tables of useful data. This little handbook should be well received by all those interested in electric lighting.

"The Mill by Stony Brook," by D. F. M., tells in a very entertaining way the story of the establishment in the early 1880's of a rubber mill in Roxbury, Mass., of the invention of the vulcanizing process, the incorporation of the Goodyear Manufacturing Co. in 1845, and its change in 1847 to the Boston Belting Co., by application to which company the brochure may be had at no charge.

BETTER INDUSTRIAL LIGHTING

An instructive bulletin with the title "Better Industrial Lighting" has just been issued by the publication committee of the National Electric Light Association. It discusses such subjects as the effect of light on production, light vs. spoilage, accident prevention, the cost of better lighting and how to solve the lighting problem. The bulletin is intended primarily for distribution by member companies.

UNITED STATES STANDARD BAUME HYDROMETER SCALES

What the Baumé hydrometer scale used in measuring the densities of liquids is, how it originated, how it has been standardized and how it may be converted to or derived from the specific gravities is explained in Circular No. 59, of the United States Bureau of Standards. Formulas for determining the degrees Baumé from the specific gravities and tables of the relation between Baumé degrees and specific gravity for liquids both heavier and lighter than water are given.

Engineers are interested in this subject on account of the use of the scale for measuring the densities of oils, both lubricating and fuel, of media for refrigerating systems, etc. Copies of the bulletin may be had free by those interested, by applying to the United States Bureau of Standards, Washington, D. C.

Recent Court Decisions

Digested by A. L. H. STREET

A Contract for Electric Power—The Pennsylvania Supreme Court has been called upon to determine legal rights under a contract by an electric company to furnish "electric power sufficient to operate not more than three double-truck cars at any one time" for a traction company. The traction company refused to make payment under the contract, asserting that the power furnished was insufficient. Thereupon the power company declined to furnish more current, and the traction company sued to compel performance of the contract and to ascertain what amount was due under the contract. Afterward power was furnished continuously while the suit was pending. Under these circumstances, the court holds that the trial judge properly allowed the power company to recover the full contract price, less any amount necessarily expended by the traction company in procuring power to make up any deficiency in that furnished under the contract. (Irwin-Herminie Traction Co. vs. West Penn Electric Co., 96 "Atlantic Reporter," 719.)

Use of Streams for Power Purposes—In a decision which sustains the right of a water-power company to enjoin a downstream landowner from so encroaching upon the stream as to interfere with the operation of the power company's dam, the Indiana Appellate Court lays down cardinal principles of law applicable to private use of the waters of a stream. The court recognizes that the right of an owner of land bordering a river to use the stream for power purposes may exist concurrently with the public right of navigation, but that when a stream is navigable, the right of navigation is paramount and that use of the waters must be such as does not materially interfere with navigation. Finding that the defendant, a manufacturing company, had gradually encroached upon the St. Joseph River in Indiana by depositing waste material therein and by constructing buildings on the reclaimed land to the prejudice of the plaintiff in the operation of its water-power plant, the court decided that the plaintiff was entitled to sue to abate the obstruc-